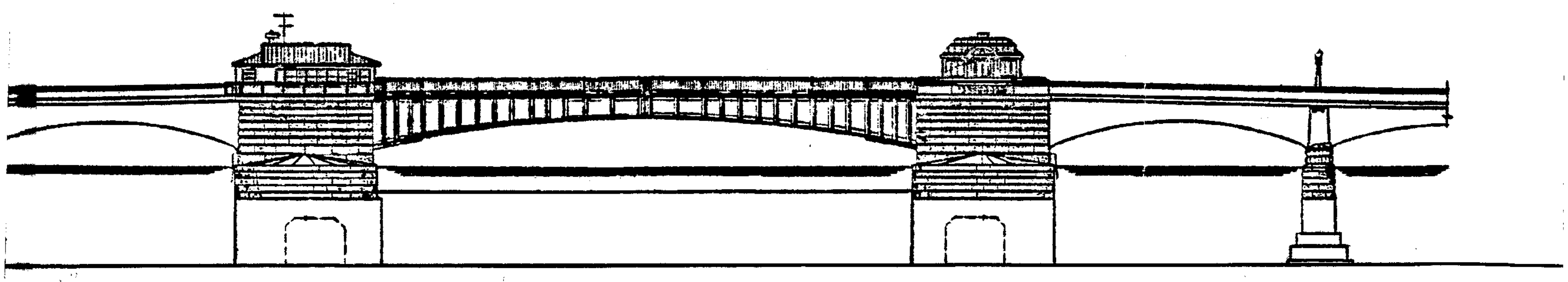
Connecticut. Coastal Zone Management Program

Regional Planning Agency of
South Central Connecticut

RAIL AND THE HARBOR

July, 1984

FREIGHT SERVICE TO NEW HAVEN HARBOR



The fifteen town South Central Connecticut Region is composed of Bethany, Branford, East Haven, Guilford, Hamden, Madison, Meriden, Milford, New Haven, North Branford, North Haven, Orange, Wallingford, West Haven and Woodbridge. Area-wide land-use and transportation planning for the region is performed by the Regional Planning Agency of South Central Connecticut, 96 Grove Street, New Haven.

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RAIL AND THE HARBOR

Freight Service to New Haven Harbor

Regional Planning Agency of South Central Connecticut
New Haven, Connecticut
July, 1984

REGIONAL PLANNING AGENCY OF SOUTH CENTRAL CONNECTICUT

96 GROVE STREET NEW HAVEN, CONNECTICUT 06510 TELEPHONE 777-4795

July 27, 1984

Mr. Anthony Milano
Secretary
Connecticut Office of Policy and Management
80 Washington Street
Hartford, Connecticut 06106

Dear Mr. Milano:

An OPM-administered "Coastal Energy Impact Program" project has provided an opportunity to define how rail improvements can help make better use of New Haven port facilities. We hope that proposals can help develop a joint public and private sector consensus relative to the nature and urgency of necessary improvements.

Rail and New Haven Harbor suggests how to improve the Tomlinson Bridge and approaches, re-establish efficient rail service to the east shore and improve freight handling capabilities. Assistance provided by Seelye, Stevenson, Value and Knecht (Stratford, Connecticut) has been of immeasurable help. SSVK personnel are intimately familiar with the Tomlinson Bridge, have extensive rail operations experience and are actively engaged in a number of rail facility design projects.

We appreciate the opportunity offered by the CEIP program and, in particular, the assistance provided by Bill Cox of your office.

Very truly yours,

Donald G. Byers

Donald G. Byers
Chairman

DGB/dgs

cc: New Haven--Mayor B. DiLieto
ConnDOT--Commissioner J. W. Burns

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1. SUMMARY

A $7 million investment can maintain an important 115-year old rail freight link across New Haven Harbor. Improvements to the Tomlinson Bridge and its approaches can

- preserve east shore service. The Northeast Rail Services Act fixes Conrail's east shore commitment through early 1986. Neither Conrail nor a successor can be expected to offer attractive service without major physical improvements which permit modern equipment carrying reasonable loads to reach the east shore.

- make east shore rail freight service competitive. Longer trains and heavier loads can supplant current one car at a time 200,000 pound car (car plus load) limits. Weight limits alone restrict individual cars to loads between one-half and two-thirds of possible capacity.

- take advantage of the harbor's natural advantages. Improved rail links favor service to more remote markets. Location, natural features and investment combine to make New Haven Harbor a good facility for specialized commodities. Well-established liquid cargo (petroleum and chemicals) handling capabilities can be used more intensively. Good opportunities exist to handle bulk commodities including scrap, lumber and possibly coal in volume.

- complement other necessary expenditures. Two million dollars have been spent since 1973 to rehabilitate the Tomlinson Bridge lift mechanism, repair the lift span and install a fender system. Another $10 million investment will be necessary before 1990 to maintain U.S. 1 highway traffic on the bridge. Another $7 million spent in concert with a comprehensive $10 million bridge rehabilitation project can provide necessary rail capacity.

A near-term rail improvement program which focuses on existing facilities can create new capacity faster, at less cost and with less disruption than otherwise possible. Commodities, freight car requirements, track alignment, clearance, grades and engine capabilities shape improvement needs. A contemporary environment must accomodate multi-car trains composed of 263,000 pounds (loaded) cars up to 65 feet in length and present curves with a radius of at least 460 feet (12 degrees, 30 minutes).

2. THE CURRENT ENVIRONMENT

A 145-year legacy shapes rail service options. Facilities reflect decisions of the Hartford and New Haven Railroad Company which originally brought service to New Haven and Belle Dock in 1839 and extended service over the Tomlinson Bridge in 1870.(1) Later investment by the New York, New Haven, and Hartford Railroad (successor to the Hartford and New Haven in 1872), waterfront interests and the City of New Haven created the contemporary environment. Facilities have remained largely intact since 1926 when the City of New Haven completed construction of the fourth Tomlinson Bridge at the present location and grade-separated Water Street and the Belle Dock spur.(2)

An East Shore Rail Focus

Long-term city development policies and emerging project commitments make east shore rail service important (Figure 1). West shore areas with relatively good rail service are largely committed to non-maritime activities which have relatively little use for rail. East shore sites with favorable long-term maritime potential depend on rail movement to and from the west shore. Sixty percent of

(1) Manufacturer's Railroad facilities which included the Belle Dock spur were deeded to the New Haven Railroad in 1901. Original (1839) Hartford and New Haven Railroad Company operations established Belle Dock as a terminal linking New York City-to-New Haven boat service and New Haven-to-Hartford and Albany rail service. The Railroad acquired a majority interest in the Tomlinson Toll Bridge Company at the same time. Passenger facilities were relocated from Belle Dock to a joint New York and New Haven Railroad station in 1849. Belle Dock ship-to-rail freight handling capabilities were expanded in 1868 when a 1,500 foot long, 80 foot wide extension was constructed--just four years before the New Haven-Hartford and New York-New Haven railroads merged. Rail and harbor development are traced in: New Haven Historical Society "Books 134 thru 157" (miscellaneous microfiche materials); in Frederick Ford, Report on a Railroad Station Approach and Harbor Front Improvements, prepared for the Mayor and Aldermen (New Haven: City of New Haven, 1912); and in Sidney Withington, New Haven and Its Six Railroads, undated Railway and Locomotive Historical Society monograph.

(2) Two wooden bridges served from 1798 to 1887 before a cast iron truss bridge (swing span) originally used in rail service over the Housatonic River replaced the second (1842) Tomlinson Bridge span. Tolls were removed in 1886 when the city became owner of the bridge. Design of the current bridge, constructed at a cost of $1,000,000 to the City of New Haven, was essentially completed in 1917.

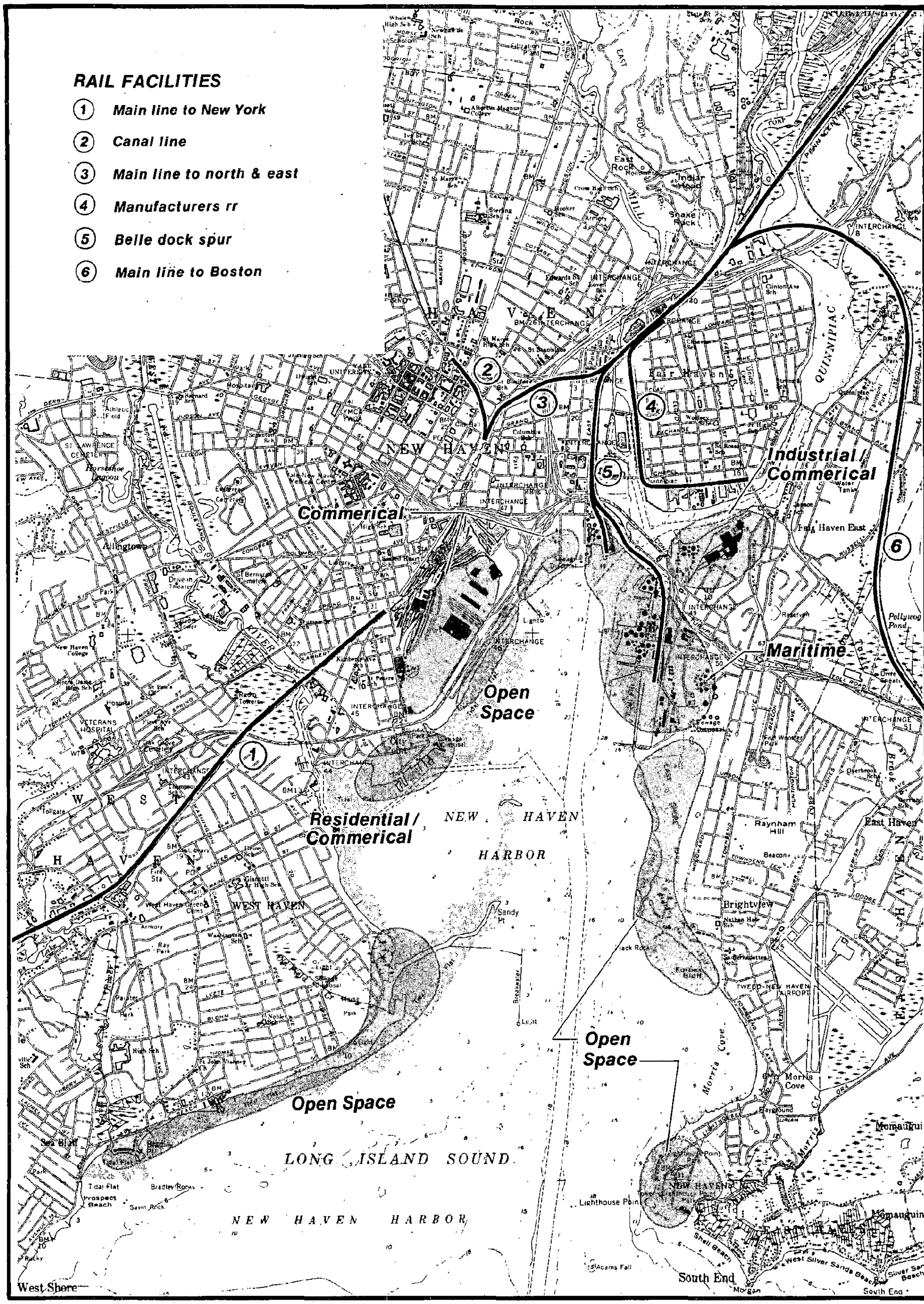

Figure 1: Harbor Development Policies. Long-term city policies and emerging project commitments make east shore rail service important. East shore sites with favorable long-term maritime potential depend on rail movement to and from the west shore.

New Haven's waterfront petroleum storage capacity is concentrated in east shore areas; it depends on rail service which is fundamentally more expensive to provide and has been subject to substantial interruption (Figure 2).(3) Unreliable service and high cost movement preclude major rail shipments like those of Wyatt Fuel on the west shore. Dry cargo handling capabilities and storage capacity are similarly focused on the east shore at the 45 year old New Haven Terminal.(4) New Haven Terminal's near-term expansion on to an adjacent 43 acre former U.S. Steel site enhances the long-term rail freight market.(5)

Right-of-Way

The 1982 rail service reorganization process encouraged by the New England Rail Services Act of 1981 left Conrail in continued control of all main line and most spur facilities in the New Haven area.(6) Conrail ownership and exclusive operating rights to the two Belle Dock tracks linking New Haven Harbor to the Amtrak main line (one mile) and the Cedar Hill Yards 3.3 miles away remain intact (Figure 2). Conrail Belle Dock service obligations were extended through early 1986 and a

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(1) New Haven City Plan Department, Petroleum Storage for New Haven Harbor: Waterfront Versus Inland (New Haven: City Plan, 1980), pp. 59-61.

(4) TAD Jones' (coal) 1940 purchase of the former New Haven Silk Mills building (constructed in 1921) began the consolidation of the New Haven Terminal.

(5) New Haven acquired the 43 acre property at a cost of $2,250,000 in mid-1983. A $2.0 million demolition and site improvement program began in late 1983. State "Municipal Development Project" aid ($1.1 million), City resources ($750,000) and a $2.4 million New Haven Terminal purchase price will help fund the $4.3 million program. New Haven Terminal will acquire the site in mid-to-late 1984.

(6) Belle Dock spur facilities were addressed as "New Haven Station"--all rail properties within the corporate limits of the City of New Haven. See: Special Court Regarding the Rail Reorganization Act of 1973, Order Approving and Directing the Consummation of Expedited Supplemental Transactions, April 13, 1982. Canal Line ownership was transferred to the Boston & Maine Railroad per a joint Conrail/B&M proposal. Conrail agreed to forego branch line surcharges in Connecticut during the four year term of the agreement.

Figure 2: Major Shippers. Major harbor facilities served by rail from the Cedar Hill Yards (1) or within reach of rail service include (2) United Illuminating, (3) Exxon, (4) New Haven Terminal, (5) Arco, (6) TAD Jones, (7) Gulf Oil, (8) Texaco, (9) Mobil Oil, (10) the former U.S. Steel site to be acquired by New Haven Terminal, (11) Wyatt Fuel, and (12) Elmco (fuel).

right of succession by the Providence & Worcester Railroad established.(7)

Railroads and shippers encounter right-of-way constraints which limit east shore loads and raise unit costs. Constraints include:

- poor east shore curvature. Curvature and, to a lesser extent, light weight rail, restrict both car size and train length. Maximum car lengths on the east shore are restricted to 50 feet in contrast to 65 foot cars that can be brought from the Cedar Hill Yards to Belle Dock and on to Wyatt Fuel tracks. Fifty foot car lengths suffice for many common commodities but prove inefficient for light density goods (see Part 3). Sharp curves at Belle Dock--Forbes Avenue (22 degrees or 260 feet), Forbes Avenue--Waterfront Street (40 degrees or 143 feet) and Forbes Avenue--U.S. Steel (38 degrees or 151 feet) limit train lengths (Table 1). For all practical purposes, the advent of 50-foot freight cars made New Haven Terminal and the U.S. Steel site inaccessible to multi-car trains.

- a 200,000 pound per car weight limit on the Tomlinson Bridge. Current 200,000 pound (car plus load) weight limits on the Tomlinson Bridge were imposed by the Connecticut Department of Transportation--the owner of the bridge. Original (1917) bridge plans and specifications sought to accomodate then current 200,000 pound cars although design assumptions may have overstated structural capabilities. Contemporary freight cars with 200,000 pound loads carry only 60 to 75 percent of the effective payload otherwise accomodated within the bounds prescribed by the Association of American Railroads' 263,000 pound interline weight maximum.

- relatively severe grades. Grade, curvature and engine capabilities have historically limited the load or "string" of cars that can be carried across the bridge. Engines approaching Forbes Avenue must overcome grade, load, curvature and inertia--they start without the benefit of perceptible momentum. A two percent east shore and 2.3 percent west shore approach grade control. Pre-WW II 50-ton electric engines which gained power from overhead trolley lines

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(7) Special Court, Section 21. B&M is guaranteed "...continued access to property it may acquire within New Haven station...in the event P&W succeeds Conrail." Nevertheless, competitive harbor rail service might be better assured by a "switching railroad" linking Cedar Hill facilities and the harbor.

MINIMUM CURVATURE					
Length of Car Over Pulling Faces of Couplers	**Minimum Required Radius**	**Acceptable at**			
		BELLE DOCK — FORBES AVE.	**FORBES AVE. — WATERFRONT ST.**	**FORBES AVE. — U.S. STEEL**
Less than 50'	185'	yes	no	no
50' to 56'	215	yes	no	no
56' to 63'	250	yes	no	no
63' to 70'	275	no	no	no
70' to 75'	300	no	no	no
over 75'	350	no	no	no

Table 1: Minimum Curvature. Minimum curves for coupled cars of the same length are illustrated. Only the 260-foot radius west shore curve from Belle Dock provides reasonable turning conditions for 50 to 60 foot cars. (Source: Association of American Railroads, The Car and Locomotive Cyclopedia of American Practices (Omaha, Nebraska: Simmons-Boardman, 1980), Section 2.)

towed only three to four circa 170,000 pound cars (car plus load) across at one time. Short modified diesel engines introduced in 1948 trailed six-to-eight 40-to-45 foot fully loaded 200,000 pound cars (100,000 to 170,000 pound loads).(8) Similar service continued into the 1960's until 50-foot long cars became the industry norm and could not negotiate severe east shore curves as multi-car units.

- vertical clearance. East Street spur clearances are not unduly restrictive relative to commodities and freight cars. A 16-foot Belle Dock clearance restriction at Chapel Street (west track) controls the vertical dimension when both east and west tracks are operative (Figure 3). Low speeds which control "wobble" can bring cars to within two to three inches of overhead obstructions. Common box, gondola and tank cars share a 15-foot 6-inch height. Only "high cube" equipment (circa 10,000 cubic foot box cars) effective for light weight products is prohibited. Seventeen-foot, 6-inch "high cube" cars are occasionally received at Cedar Hill Yards.

- miscellaneous track and road bed problems. Sporadic maintenance and years of minimal right-of-way investment account for: (1) frequent flooding at Chapel Street which requires pumping. Winter icing conditions prove difficult (time consuming) to combat; (2) uneven roadbed--particularly adjacent to Wyatt Fuel receiving tracks--which results in derailments. Wyatt renews ties and ballast at 10-year intervals while no comparable Conrail maintenance on adjacent tracks is offered;(9) and (3) trolley type switches and tracks on both the Manufacturer's Railroad spur and on the Belle Dock extension. Maintenance requires scavaging and/or handcrafted repair. Rails embedded in Forbes Avenue without proper ballast or ties generally maintain alignment. If disturbed, both ties and heavier rail will be necessary.

A combination of larger, more cost effective rail equipment and aging rail facilities have gradually eroded the east shore rail market.

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(8) Series 800 and 900 diesels supplanted electric engines after World War II. Retired steam engines (125,000 pound K class "Moguls") used elsewhere in the New Haven system for pre-WW II switching could not be used at Belle Dock due to long wheelbases.

(9) Wyatt's efforts are offset by the necessity of switching Wyatt cars back and forth between Wyatt and Conrail tracks--derailment of Wyatt bound cars occurs in any case.

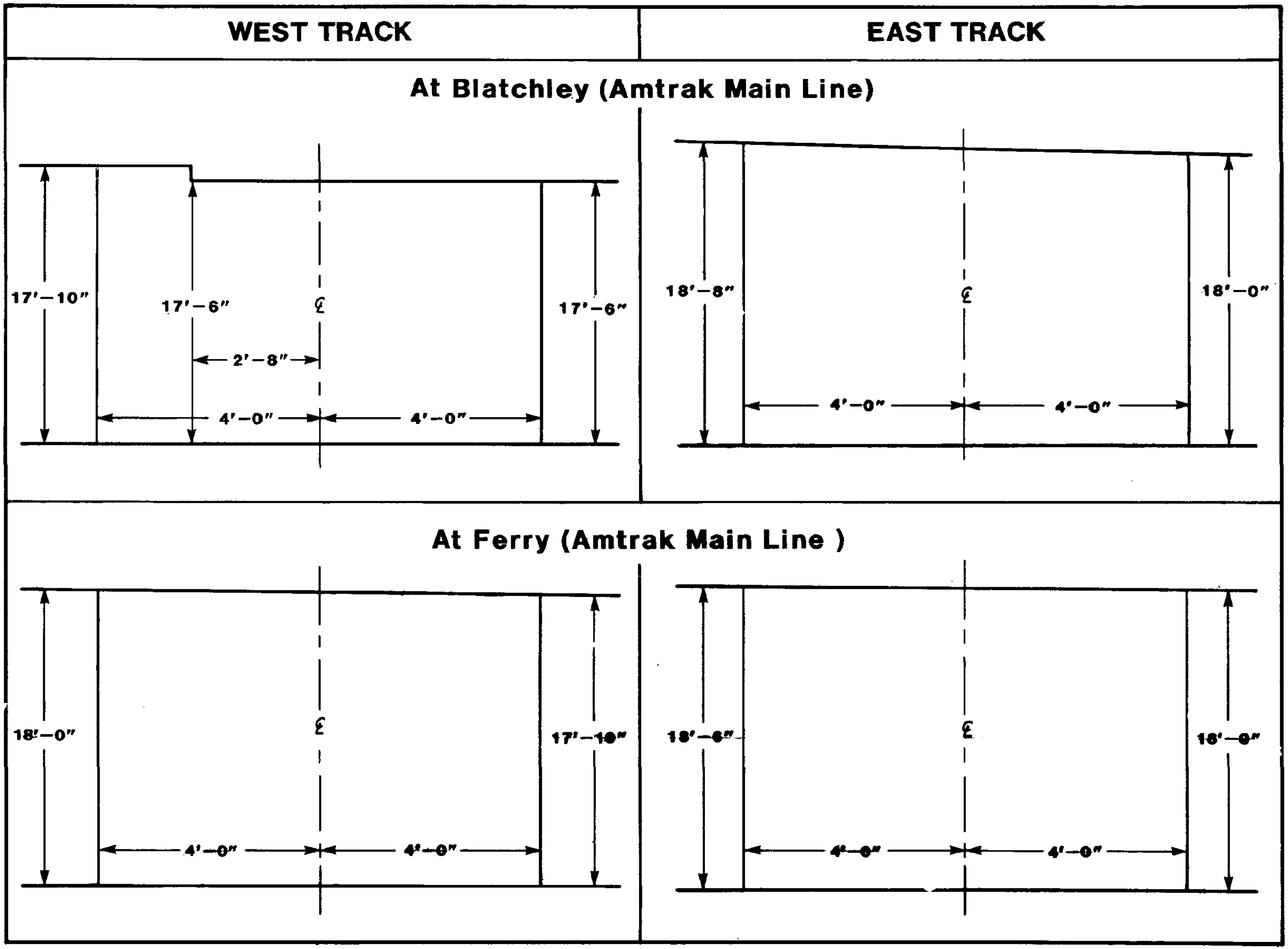

Figure 3: Vertical Clearance. A 16-foot clearance at Chapel Street generally governs car choice. Clearance dimensions are from the top of rail to the underside of roadway structure (not to scale). Clearances are not unduly restrictive.

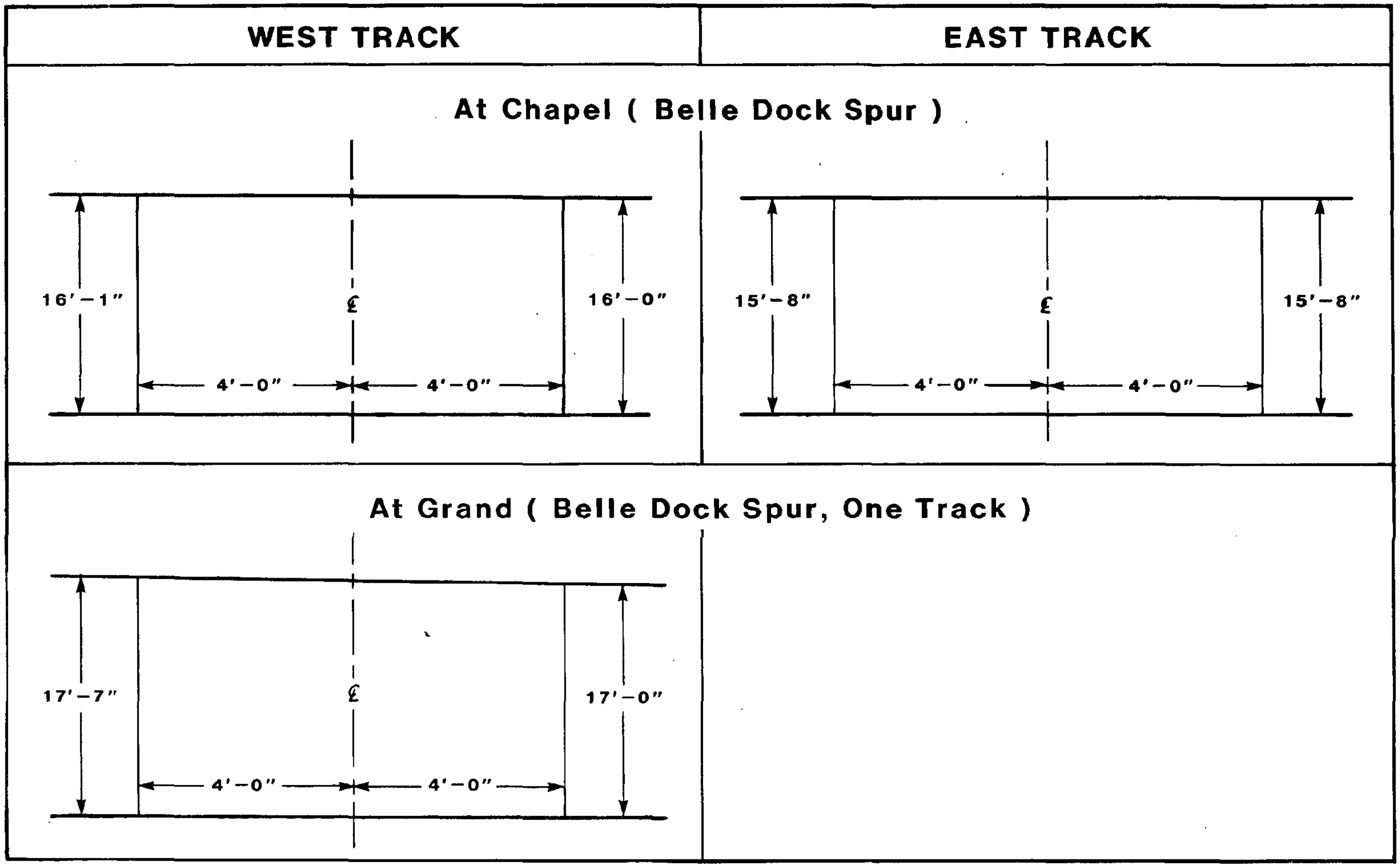

Figure 3 (con't): Vertical Clearance. Main line clearances are more generous than those along the Belle Dock Spur. (Not to scale)

Service to the Harbor

Conrail continues to offer weekday "as needed" service to both Belle Dock and the east shore despite a high cost service environment. Approximately 4,000 loaded cars (in plus out) moved through Belle Dock as recently as 1978 with 600 cars bound for the east side of the harbor.(10) Wyatt Fuel (approximately 2,300 annual cars) is clearly the dominant shipper--often generating 100 tank cars a week during the peak winter season when Millstone's nuclear fuel generating plant is off-line and oil is shipped to Northeast Utilities' West Springfield and Holyoke generating stations. Other major shippers include the New Haven Register which ships newsprint to a Davis Street warehouse; the Southern Connecticut Gas Company which receives liquid propane during the heating season; Dupont's River Street facility and Excello at New Haven Terminal.(11) Somewhat less freight now moves over the Tomlinson Bridge in the absence of U.S. Steel (formerly 260 cars a year) and Pittsburgh Plate Glass (100 cars annually) east shore facilities.(12)

Current operations:

- move all cars from Cedar Hill as one "cut"--switching at Belle Dock as necessary. Cars moving over the Tomlinson Bridge are switched as a "block." Only Wyatt ships a sufficient number of cars to arrive as block from Cedar Hill. Wyatt cars are blocked in units of six since Wyatt's sidings accomodate a maximum of six cars each. Car storage at Belle Dock did not represent a problem during the high volume era. Movement into and out of Belle Dock was managed to balance demand.

- use relatively light (200,000 pound) SW1 class switching engines (8400 and 8500 series) because of ConnDOT-imposed weight limits. Heavier 260,000 pound switching engines which develop "adhesion" equal to about 25 percent of their weight at low speed can provide about 60 percent more "tractive effort"--effective pulling

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(10) New Haven City Plan Department. The Tomlinson Bridge Rail Link: Economic Impacts and Need for Improvements (New Haven: City Plan, 1979).

(11) The New Haven Register is considering direct newsprint shipment via the yards adjacent to Union Station (New Haven). Some new track is necessary.

(12) Weight restrictions and unreliable operating conditions during the late 1970's reportedly led PPG to relocate. Caustic materials had been sent westward from the waterfront area.

force necessary to overcome resistance.

- repressurize air brake systems at Belle Dock before moving on to Forbes Avenue. Air coupling and pressurizing a string of 10 to 12 cars takes between 15 and 20 minutes--circa one minute to couple each pair of cars and five minutes to pressurize the string.

- proceed over the Bridge and Forbes Avenue at about 10 miles per hour. Service is provided over the bridge between 8:00 AM and 4:00 PM without any particular attention to competing vehicular traffic needs. Vehicular traffic is stopped by a flag to permit trains to enter Forbes Avenue. Two-way traffic is resumed while a train crosses the Quinnipiac River and traffic is stopped again when the train returns to its own right-of-way.

- "block" (arrange) cars relative to Federal Railroad Administration high hazard shipping restrictions. Cars transporting corrosive or combustible products to the east shore often require a spacer behind the engine. Spacers, limited curvature and poor track increase the possibility of derailment.(13)

Weight and operating restrictions establish a high cost switching environment. One-at-a-time movement slows operations and raises costs. Seventy minutes are required for each one-way car round trip to the east shore. Daily service between Belle Dock and New Haven Terminal is limited to six cars (each way, twelve movements).(14) High switching costs limit the contribution of

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(13) Federal Railroad Administration high hazard shipping requirements established in Title 49, CFR, Parts 171, 172, 173, 174 and 179. Cars carrying products categorized as explosives (explosives A), poison gases, combusitbles and radioactive materials cannot be placed next to an engine. "High hazard" cars are normally placed "...not nearer than the sixth car from the engine..." Tomlinson Bridge one-at-a-time constraints dictate the use of "spacers" for selected commodities including flammable liquids (not petroleum), gases, corrosive materials (including caustics) and certain non-flammable gases.

(14) Seven working hours during 8:00 AM and 4:00 PM without overtime. Conrail necessarily leaves cars on a "run around" track at New Haven Terminal because curves on sidings are too limited for Conrail engines. A New Haven Terminal owned and operated "donkey engine" moves each car to a siding. New Haven Terminal sidings can accomodate about 55 cars at a time. Unloading facilities and temporary on the ground storage of solid cargoes permit a relatively fast turn-around within the Terminal.

east shore revenue toward other terminal and system-wide costs.(15) Nevertheless, Conrail continues to offer service "as needed" generally twice a week) without imposition of a surcharge which might reflect low volume--high cost operating conditions.

(15) Conrail views the east shore service in terms of marginal or avoidable costs vs. average revenue--not in terms of marginal revenue earned from the service which might not otherwise be gained. See Conrail, "Belle Dock Economic Study" (November, 1978).

Shippers and railroads share burdens imposed by an outmoded physical plant. Unreliable east shore service and limited payload capabilities prevent terminal operators from quoting competitive rates for products most economically shipped to and from the port by rail. Short range marketing plans cannot dismiss the possibility of a surcharge. A high cost operating environment makes rail service equally unattractive to railroads.

Cars and Commodities[16]

Competition and efficiency require local shippers to use the largest possible cars subject to weight limits, product density and car size constraints. Progressively larger freight cars introduced over the 1900 to 1960 period have established a 263,000 pound North American inter-line weight limit (weight on rail)--a capacity of up to 100-tons (Figure 4). A voluntary decision to restrict normal interchange movements to cars of 100-ton capacity or less is likely to persist. Further weight increases are generally considered to have a strong negative impact on rail and wheel wear.

Extremely large cars have tended to become the industry standard--particularly for bulk commodities (Table 2 and Appendix A). Current 50 foot (length) cars capable of reaching the Cedar Hill Yards can typically carry twice the effective weight and 1.5 to two times the bulk of World War II era equipment (Table 3). Eighty-five percent of all tank cars are now at least 14 feet high, 20 percent are at least 70 feet long, and a third carry at least 22,000 gallons. Similarly, 90 percent of covered hoppers are at least 14 feet high, 10 percent are more than 70 feet long, and 20 percent can carry more than 5,000 cubic feet of material. A variety of freight car configurations allow shippers to maximize weight and volume--to move a loaded car as close to 263,000 pounds as possible.

Local Needs:

Typical east coast equipment capable of reaching the Cedar Hill Yards can complement the port's

(16) National overview per A. D. Little, Inc., Issues and Dimemsions of Freight Car Size: A Compendium, prepared for the U.S. Federal Railroad Administration (Washington: FRA, 1980).

specialized handling capabilities.[17] High volume commodities now moving through the port (oil, lumber, scrap and cement) can make efficient use ot 40- to 60-foot long cars with 140,000 to 200,000 pound load carrying capacities (Tables 4 amd 5). Products of potential significance including soft coal and caustic soda can similarly make good use of conventionally-sized equipment. Out-sized cars (beyond 65-feet long) designed to carry specialized manufactured goods need not be accomodated by the local rail system.

Design Requirements

Freight car configurations and loads establish alignment and structural requirements for local facilities--particularly for the Tomlinson Bridge.

Weight and Loading:

Evenly distributed loads (uniform loading) and standard 100-ton truck dimensions (5 feet, 10 inches between wheel centers) establish axle loadings for shear and moment (bending action) on a superstructure--they define the extent of support necessary to make a facility like the Tomlinson Bridge useful. Dense products (cement, scrap and coal) and short (40 to 50 foot) cars present maximum loads on key bridge elements (Figure 5). Multi-car trains composed of 263,000 pound cars and a 252,000 pound locomotive will load (produce greatest reactions on) successive sections relative to axle arrangement and Tomlinson Bridge design elements (Appendix C).[18] Cars rather than engines tend to control due to weight and axle arrangements. Reactions

- produce a maximum moment on span 1 approximately 26 feet from the west abutment (2,570 foot kips).

- "load" the cantilever in span 2 with two axles at the end of the cantilever and two axles on an adjacent "hung" girder (3,590 foot kips).

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(17) Historic petroleum handling commitments, limited land area, a decline in heavy manufacturing and proximity to New York and Boston define the port's role. See: New Haven City Plan Department, The Port: Background Paper No. 6, prepared for the Coastal Planning Steering Committee (New Haven: City Plan, 1981).

(18) A quick check by Seelye, Stevenson, Value and Knecht; e.g. without benefit of cantilever counteraction reducing maximum positive moment in spans 1 and 6. See Appendix C.

FREIGHT CARS					
Car - Trucks	Cubic Capacity (feet) (1)	Light Weight (lbs) (2)	Capacity (lbs)	Dimensions	
				HEIGHT (3)	LENGTH (4)
BOX					
50' -- 70 ton	5,277	62,100	154,000	15-4	52-10
60' -- 100 ton	6,488	82,200	180,000	15-4	63-11
80' -- 100 ton	10,000	114,500	148,000	16-12	87-10
GONDOLA					
50' -- 100 ton	2,244	64,300	197,000	8-1	54-5
50' -- 100 ton	4,000	62,200	200,000	12-2	50-5
60' -- 100 ton	3,242	71,800	190,000	9-1	68-4
50' -- 70 ton	2,150	54,600	140,000	6-11	54-8
OPEN TOP HOPPER					
50' -- 70 ton	2,700	50,700	170,000	11-0	41-8
40' -- 100 ton	3,420	59,900	200,000	12-2	46-1
50' -- 100 ton	3,749	64,000	197,000	12-1	50-5
COVERED HOPPER					
40' -- 100 ton	3,000	52,000	208,000	14-7	39-3
50' -- 100 ton	4,750	61,300	200,000	15-1	57-4
60' -- 100 ton	5,820	68,500	192,000	15-4	65-7
FLAT CARS					
50' -- 70 ton	n.a.	57,100	162,900	4-11	51-3
60' -- 100 ton	n.a.	63,000	200,000	15-5	64-2
80' -- 70 ton (TOFC)	n.a.	88,200	121,800	7-10	85-8
TANK CARS (Gallons)					
40' -- 100 ton	16,000	62,900	200,100	14-9	41-7
50' -- 100 ton	23,000	74,300	188,700	14-8	52-9
70' -- 100 ton	33,800	102,200	160,800	15-6	65-5

(1) including "heap" where applicable.
(2) unloaded car.
(3) maximum dimension from top of rails.
(4) over strikers.

Table 2: Representative Freight Cars. Reasonable curves and existing clearances will allow all but "hi-cube" boxcars (10,000 cubic feet) and "trailer on flat car" equipment to reach both east and west shore areas. Car dimensions appear in Appendix A.

COMMON EQUIPMENT							
Car	Type or Series	Weight (pounds)			Cubic Capacity	Max. Dimension	
		UNLOADED CAR	MAX. LOAD	MAX. TOTAL		LENGTH	HEIGHT
BOX							
1944	36000 series	45,000	120,000	165,000	3,715 ft.	44-3	14-5
1984 (50' max.)		62,100	154,000	216,100	5,277 ft.	52-10	15-4
FLAT							
1944	42000 series	31,900	50,000	91,900	---	38-0	6-4
1984 (50' max.)		57,100	162,900	220,000	---	51-3	4-11
GONDOLA							
1944	60000 series	41,000	100,000	141,000	1,572 ft.	45-10	7-5
1984 (50' max.)		64,300	197,000	261,300	2,244 ft.	54-5	8-1
OPEN HOPPER							
1944	115000 series	41,000	100,000	141,000	1,880 ft.	34-5	10-8
1984		59,900	200,000	259,900	3,420 ft.	46-1	11-0
TANK							
1944	K series	39,200	80,000	119,200	8,200 gal.	38-6	13-0±
1984		74,300	188,700	263,000	23,000 gal.	52-9	14-8

Table 3: Common Equipment -- 1944 and 1984. Current 50-foot freight cars reaching the Cedar Hill Yards can carry twice the effective weight and 1.5 to two times the bulk of World War II era equipment. (Source: Appendices A and B).

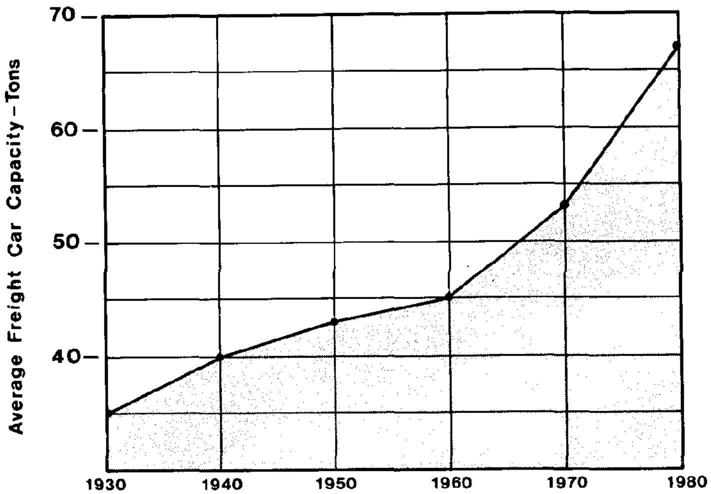

Figure 4: Average Freight Car Capacity--The Nation. The practice of replacing 70-ton cars with 100-ton cars has increased average car capacity. Source: A. D. Little, Inc., Issues and Dimensions of Freight Car Size: A Compendium (Washington: FRA, 1980.

CARS AND PRODUCTS		
Car	**Typical Products**	**New Haven Harbor Use**
BOX	manufactured goods and selected materials including wood products.	up to 65' length. Excludes "hi-cubes."
GONDOLA	wood, steel, and machinery. Coal in unit trains.	scrap in 50-55' length cars.
OPEN TOP HOPPER	Stone, ballast, ore and coal. Self-clearing feature attractive.	HK car probably necessary to clear outside at rails.
COVERED HOPPER	styrene and polyethylene pellets, cement.	from 40 to 65' lengths.
FLAT	pulpwood, plywood, plasterboard, finished lumber, steel products (covered) and TOFC.	no TOPC to remain at ± 65 length.
TANK	petroleum, caustics, acids and gases.	full size range from 40' to 65'

Table 4: Cars and Products. Current liquid cargo volumes make tank cars particularly important. Maritime opportunities could make hoppers and gondolas important.

CAR SELECTION				
Product Density	**Car - Trucks**	**Car Capacity (Load)**		**Capacity Volume - To - Weight Optimum = 1.00**
		CUBIC FT.	WEIGHT	
Anhydrous Ammonia--5.2 lb./gal.	60' tank -- 100 ton	33,800	160,800	108
Caustic Soda--12.5 lb./gal.	40' tank -- 100 ton	33,800 gal.	160,800	93
Cement--95 lb./ft.^{3}	40' covered hopper -- 100 ton 50' covered hopper -- 100 ton	3,000 ft.^{3} 4,750 ft.^{3}	208,000 205,000	137 220
Coal anthracite (hard)--94 lb./ft.^{3} bituminous (soft)--81 lb./ft.^{3}	40' open hopper -- 70 ton 40' open hopper -- 100 ton 40' open hopper -- 70 ton 40' open hopper -- 100 ton	2,700 ft.^{3} 3,420 ft.^{3} 2,700 ft.^{3} 3,420 ft.^{3}	170,000 200,000 170,000 200,000	149 161 129 139
Hardwood--45 lb./ft.^{3} (dry maple and oak)	50' box -- 70 ton 60' box -- 100 ton 80' box -- 100 ton	5,277 6,488 10,000	154,000 180,000 148,000	154 162 304
Liquid Propane--4.4 lb./gal.	60' tank -- 100 ton	33,800 gal.	160,800	93
Oil -- 8 lb./gal. (No. 2)	50' tank -- 100 ton	23,000 gal.	188,700	98
Polyethylene Pellets (plastic) -- 35 lb./ft.^{3}	40' covered hopper -- 100 ton 50' covered hopper -- 100 ton 60' covered hopper -- 100 ton	3,000 4,750 ft. 5,280 ft.	208,000 200,000 192,000	50 83 106
Scrap shredded $\pm$ 75 lbs./ft.^{3}	50' gondola -- 70 ton 50' gondola --100 ton 60' gondola -- 100 ton	2,150 2,376 3,242	140,000 200,000 190,000	115 80 68
compacted $\pm$ 100 lbs./ft.^{3}	50' gondola -- 70 ton 50' gondola -- 100 ton 60' gondola -- 100 ton	2,150 2,376 3,242	140,000 206,000 190,000	154 115 171
Softwood (dry) -- 40 lbs./ft.^{3}	50' gondola -- 70 ton 50' gondola -- 100 ton 60' gondola -- 100 ton	2,150 4,000 3,242	140,000 200,000 190,000	61 80 68

Table 5: Car Selection. Shippers try to maximize weight while railroads try to offer the smallest appropriate car. Product densities and car capacities are matched. Dense loads moving in short cars create high "loadings" for the Tomlinson Bridge. (Representative cars per Appendix A).

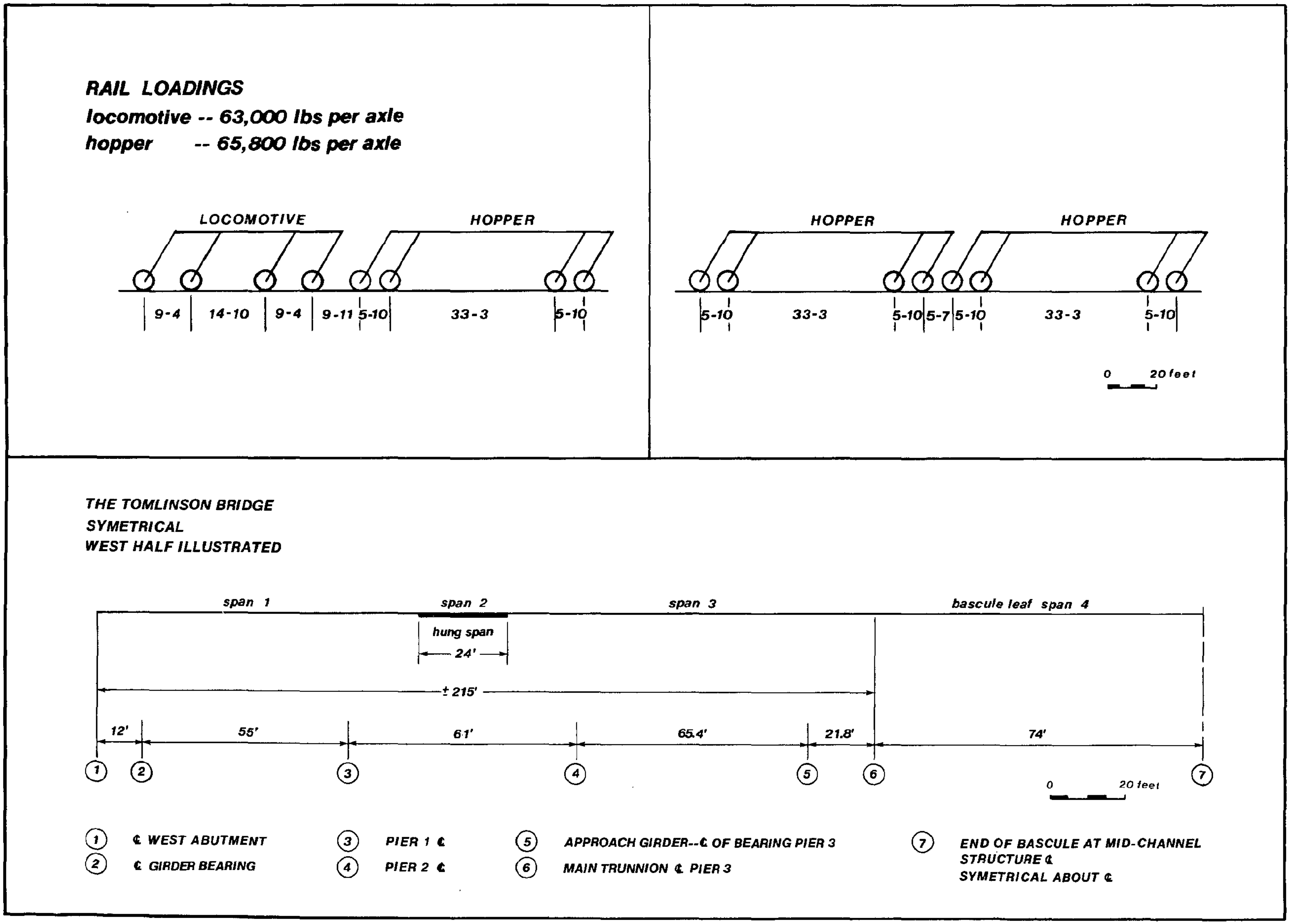

Figure 5: Tomlinson Bridge Loadings. High density commodities shipped in short cars could load each of the short center spans with about 525,000 pounds and load about 1.2 million pounds onto the longer causeway approaches.

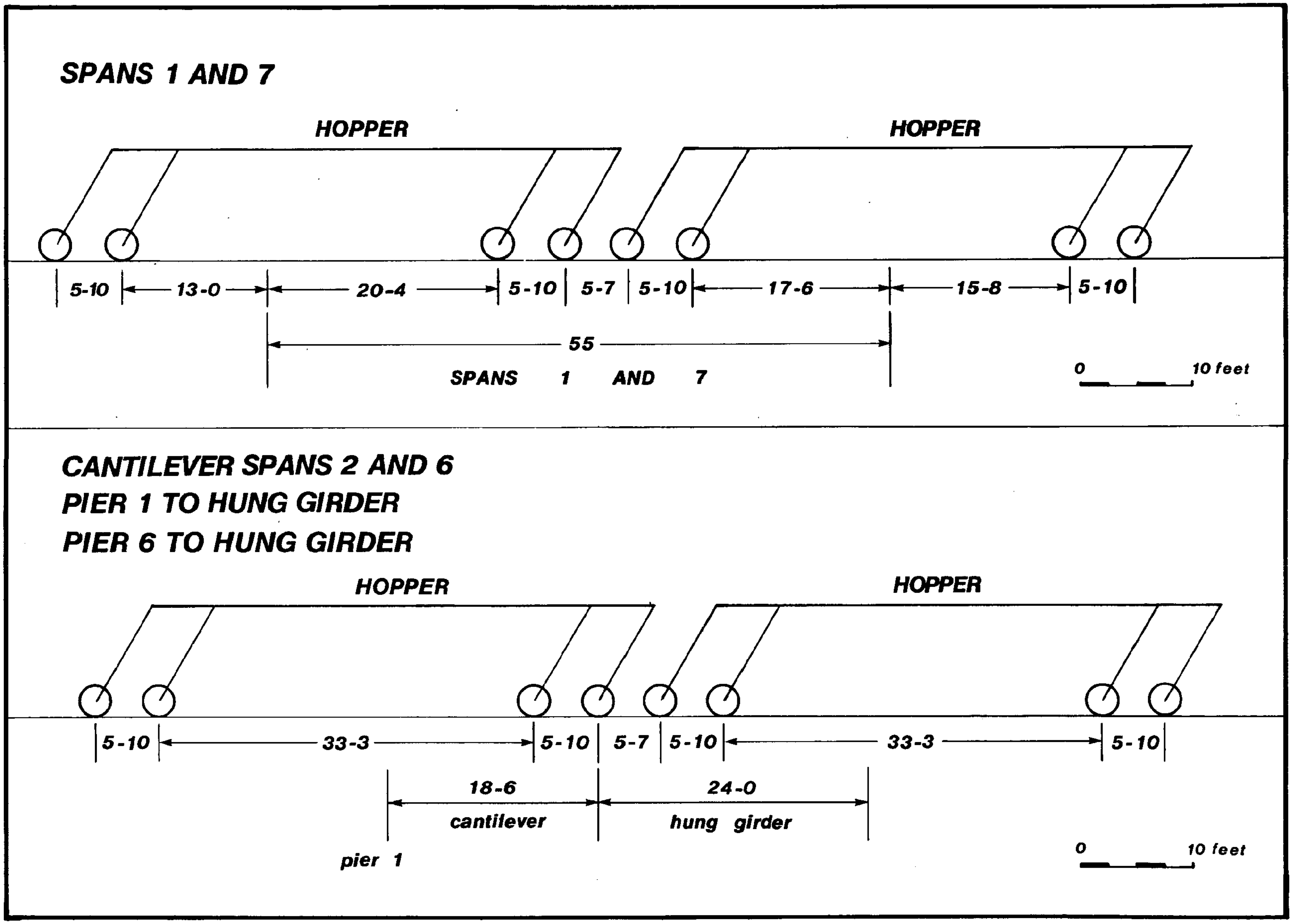

Figure 5 (Cont.): Tomlinson Bridge Loadings.

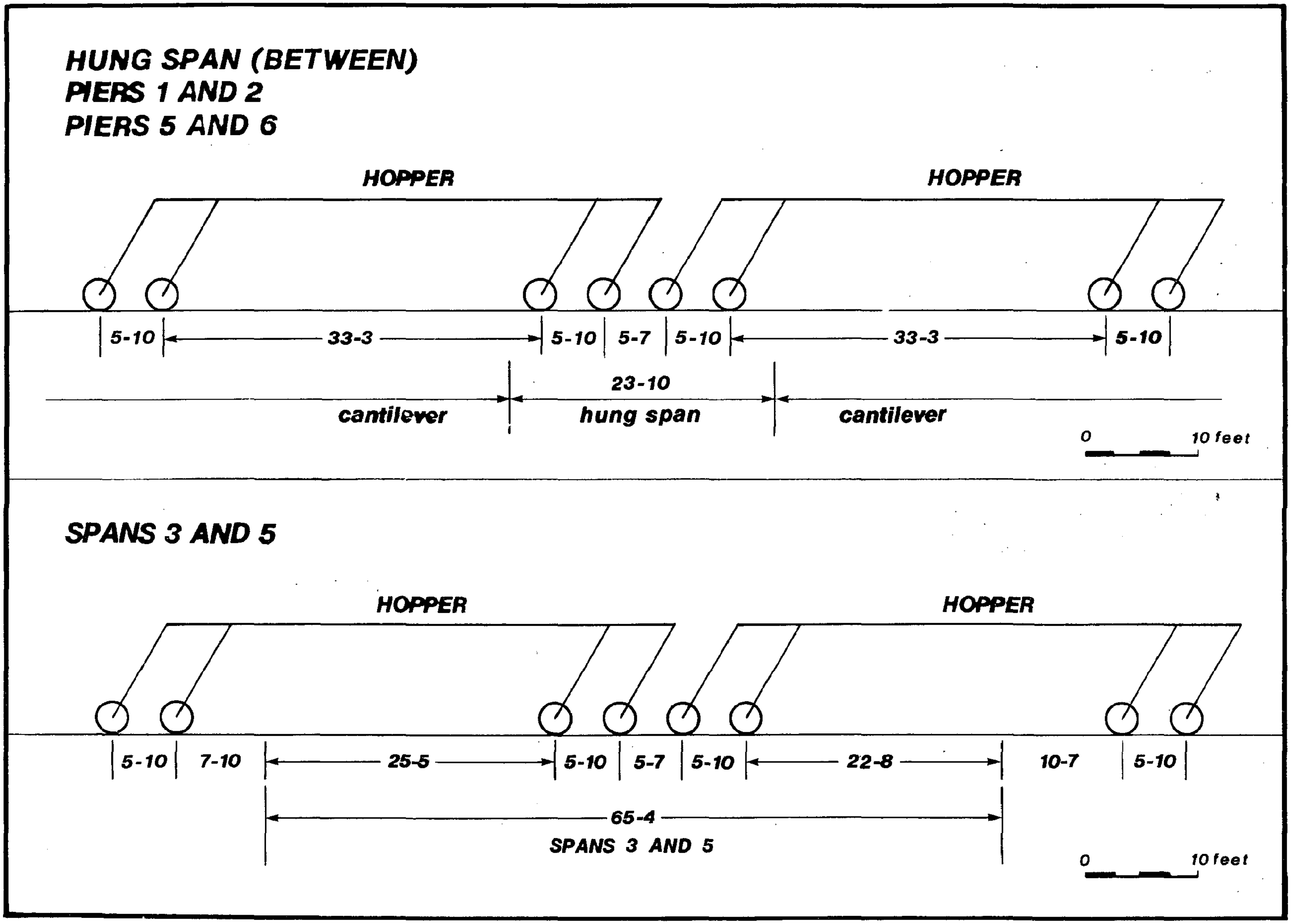

Figure 5 (Cont.): Tomlinson Bridge Loadings.

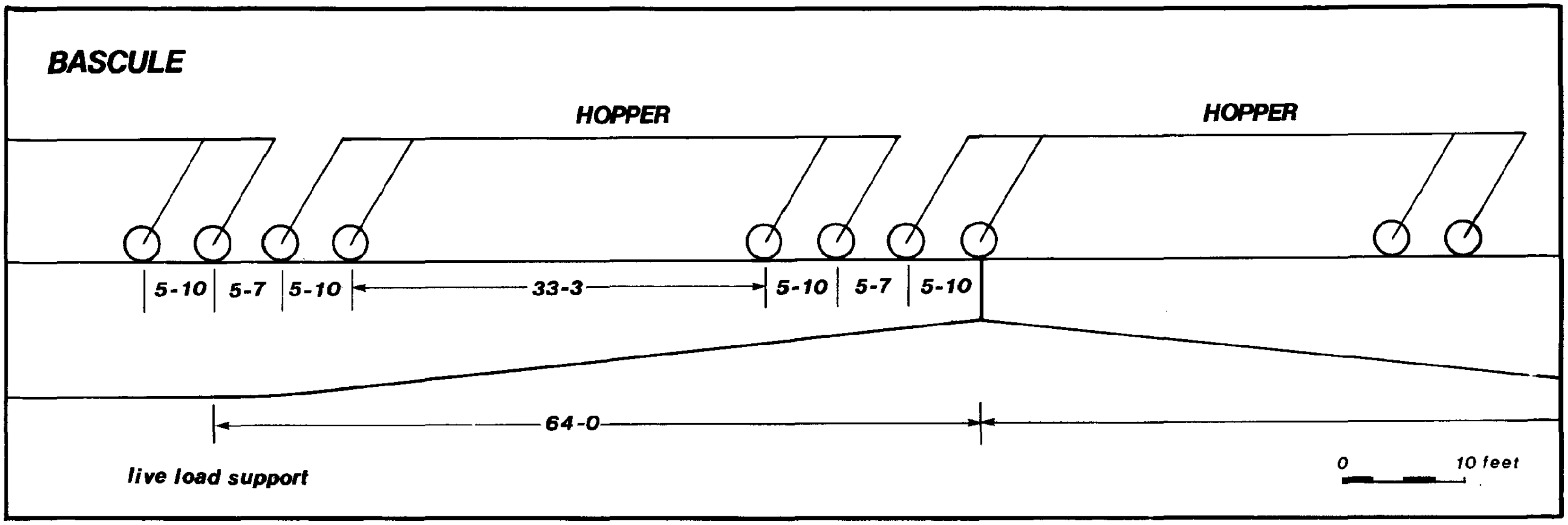

Figure 5 (Cont.): Tomlinson Bridge Loadings.

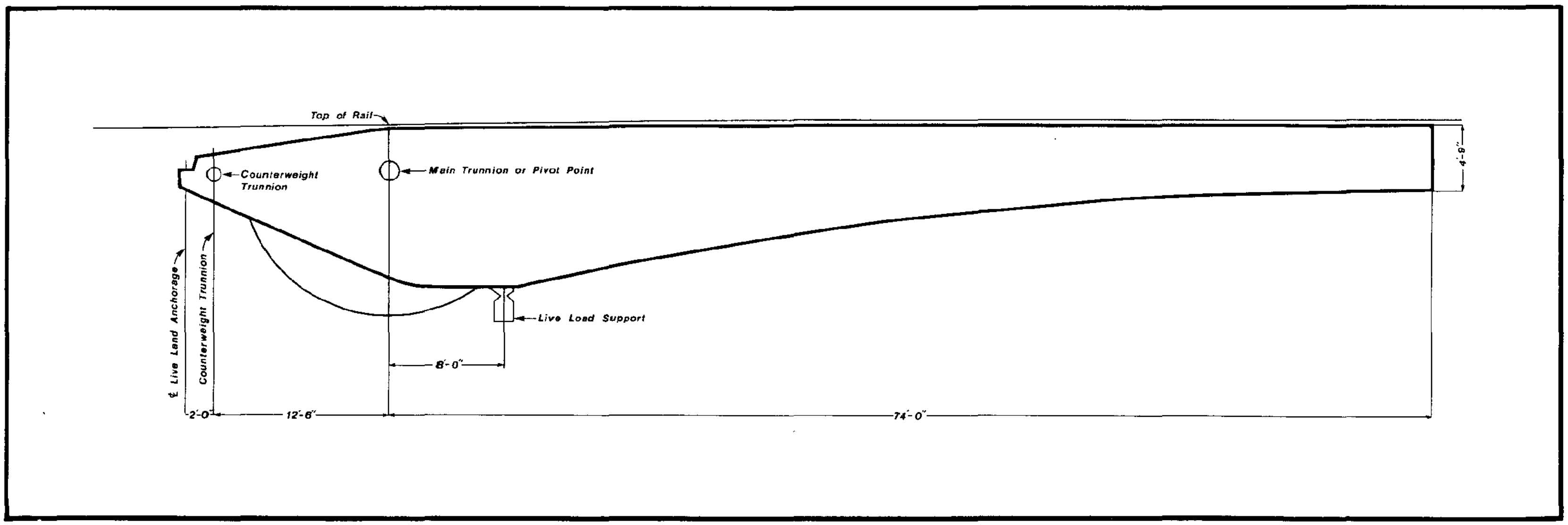

Figure 6: Lift Span Bascule Girder. The key 66-foot girder section extending from the live load support to center-span would have to accept loads imposed by seven axles. Bascule girder section properties are particularly important if a two track system is to be preserved.

- produce greatest stress on the span 2 "hung" girder with a symmetrical four axle arrangement (835 foot kips).

- create a maximum positive moment on span 3 about 31 feet from pier 2 when loaded with a rear and front axles of successive cars (3,500 foot kips).

- place a maximum load on the bascule leafs with the equivalent of a full car and the forward axles of a second car. Sections between the live load support and the end of the bascule "control" for design (Figure 6). Bascules bear loads independent of one another.

Curvature:

Operating and maintenance needs establish Conrail's normal minimum 12 degree 30 minute (459 foot) curves as practical limits despite the ability of both coupled 60-foot cars and 60-foot/40-foot car combinations to negotiate more restrictive curves.(19) Reasonable curves will

- for all practical purposes eliminate car-length and train-length restrictions in the New Haven environment--they create flexible operating conditions. Fifteen 60-foot cars could readily be accomodated.

- keep track maintenance within reasonable bounds. More severe curves and heavy cars would wear rail away prematurely.

- permit reasonable multi-car switching speeds on the spur track.

<u>Performance</u>

Grades and curves which have historically limited harborside switching operations will continue to control despite improvements. Rail capabilities are fixed by relationships between load, tractive effort (or engine pulling power) and right-of-way. About 25 percent of an engine's weight is available as tractive effort. Tractive effort consumed overcoming grades and curves is unavailable for productive purposes--for payloads.

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(19) Coupled 60-foot cars could conceivably negotiate a 26° (222 foot) radius and coupled 60-foot--40-foot cars might accept a 254 foot radius. Coupled cars of unequal length require milder curves. See Table 1.

Joint effects of grades and curves control as eastbound trains transition from Belle Dock to Forbes Avenue and westbound trains leave Water Street (Table 6 and Appendix B). Eastbound trains confronted with both a 1.4 percent grade as they move out onto Forbes Avenue and a 2.3 percent grade in adjacent tangent sections could not be longer than eight to twelve cars depending upon load (Figure 7 and Table 7).[20] Westbound engines confronted with more favorable conditions could trail between twelve and sixteen cars.

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(20) Assuming "improved" 12°30' curves, an adhesion factor of 20 to 25 percent limits low speed tractive-effort available from a 1500 hp, 252,000 pound SW 1500 locomotive likely to be used by Conrail. A 25 percent adhesion factor produces 61,500 pounds (maximum) of tractive-effort at low speeds; e.g. in the seven to 10 mph range. Tractive-effort loss associated with acceleration in the zero to ten mile per hour range over a two to three hundred foot section is negligible; ranging between 1,600 and 3,200 pounds.

WEST SHORE APPROACH Curves at 12° – 30' Car Weight (Loaded) at 263,000 Pounds 55 Foot Coupled Cars					
	Necessary Tractive Effort Due to (pounds)				Necessary Engine Weight (pounds)
	CARS	GRADE	CURVE	TOTAL	
OPTION 1: 8 CARS				66,539	266,156
on curve(1)				37,083	148,332
4 cars	10,520				
1.9% grade		19,998			
12° - 30' curve			6,575		
on tangent				29,456	117,824
4 cars	10,520				
1.8% grade		18,936			
OPTION 2: 7 CARS				61,293	245,172
on curve				37,083	148,332
4 cars	10,520				
1.9% grade		19,998			
12° - 30' curve			6,575		
on tangent				24,210	96,840
3 cars	8,430				
2.0% grade		15,780			
OPTION 3: 6 CARS				54,801	219,204
on curve				37,083	148,332
4 cars	10,520				
1.9% grade		19,998			
12° - 30' curve			6,575		
on tangent				17,718	70,872
2 cars	5,620				
2.3% grade		12,098			

(1) curve 210' with elevation from 11.5' to 15.5' or 1.9 percent tangent 210' to 20' maximum elevation, elevation from 15.5' to 20.0' or 2.1 percent.

Table 6: Necessary Engine Weight--West Shore Approach. A combination of curvature, grade and load shape the "tractive" effort necessary for switching operations. About one-quarter of an engine's weight is available as "tractive effort."

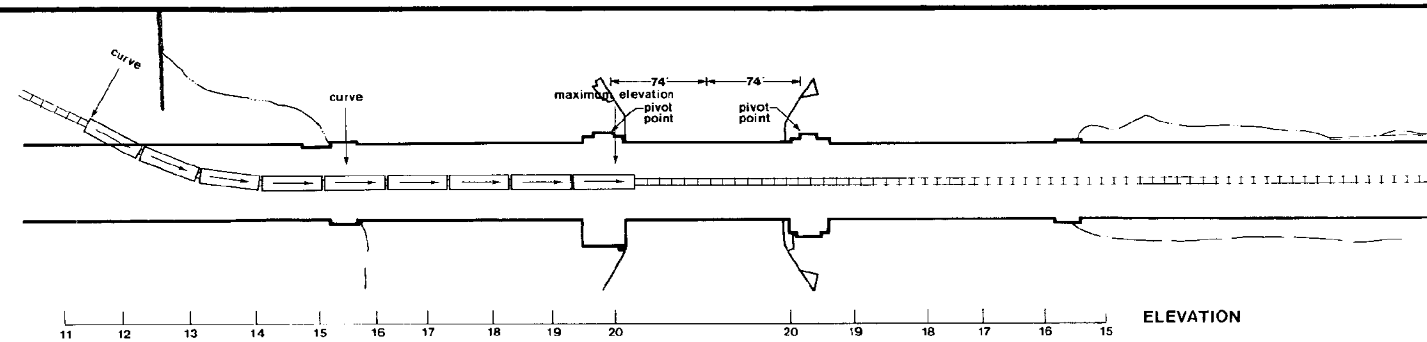


Figure 7: Grade and Curvature. Joint effects of grade and curvature will continue to control the length of "consists" despite improvements. Eastbound trains confronted with a 1.4 percent grade as they move on to Forbes Avenue and a 2.3 percent grade in adjacent tangent sections could not be longer than eight to 12 cars depending upon load.

Table 7: Effects of Grade and Curvature. Physical conditions and engine capabilities suggest a range of "consist" lengths. Twenty-five percent adhesion is achieved only under ideal conditions. A 22.5 percent rate sets reasonable performance expectations.

CARS BEHIND LOCOMOTIVE
Tomlinson Bridge

Car Type (product)	Direction	Locomotive Adhesion Factor		
		20%	22.5%	25%
23,000 gallon tanker (oil)	eb wb	7 13	12 16	16 18
50' open hopper (ore, coal)	eb wb	6 9	8 12	9 14

4. THE TOMLINSON BRIDGE

World War I era City of New Haven design efforts for the current Tomlinson Bridge sought to balance vehicular, rail freight and navigation requirements. Design efforts produced a combination of fill, 215-foot symmetrical Tomlinson Bridge approaches and twin 88-foot long double-leaf bascule spans to bridge the 1,000 foot wide Quinnipiac River (Figure 8).

Key Design Elements

Major design elements include (Table 8)

- individual approach spans consisting of variable-depth steel girders.
- a deck system of structural concrete slab supporting a concrete ballast in which railroad ties and tracks are embedded.
- a deck surface of asphalt overlay replacing the original roadway surface of creosoted paving blocks.
- four interior girders on approaches oriented so that each girder supports the wheel loads from one train of a two-track rail system.
- a double-leaf bascule at mid-channel consisting of four (4) variable-depth girders supporting trussed and/or solid floor beams with an open steel grating system. The two (2) interior bascule girders support 80 percent of the rail loading from a two-track rail system.
- limited clearance over the Quinnipiac River. The low level bridge provides a 12-foot mid-channel clearance above mean high water when closed.
- a tight knit pile pattern. Major rail "loading" problems are posed by the superstructure. A dense pile pattern suggests that the substructure should easily accomodate increased demands generated by heavier, multi-car trains.

The 42-foot wide four lane roadway created by the bridge carried 30,000 vehicles over the harbor

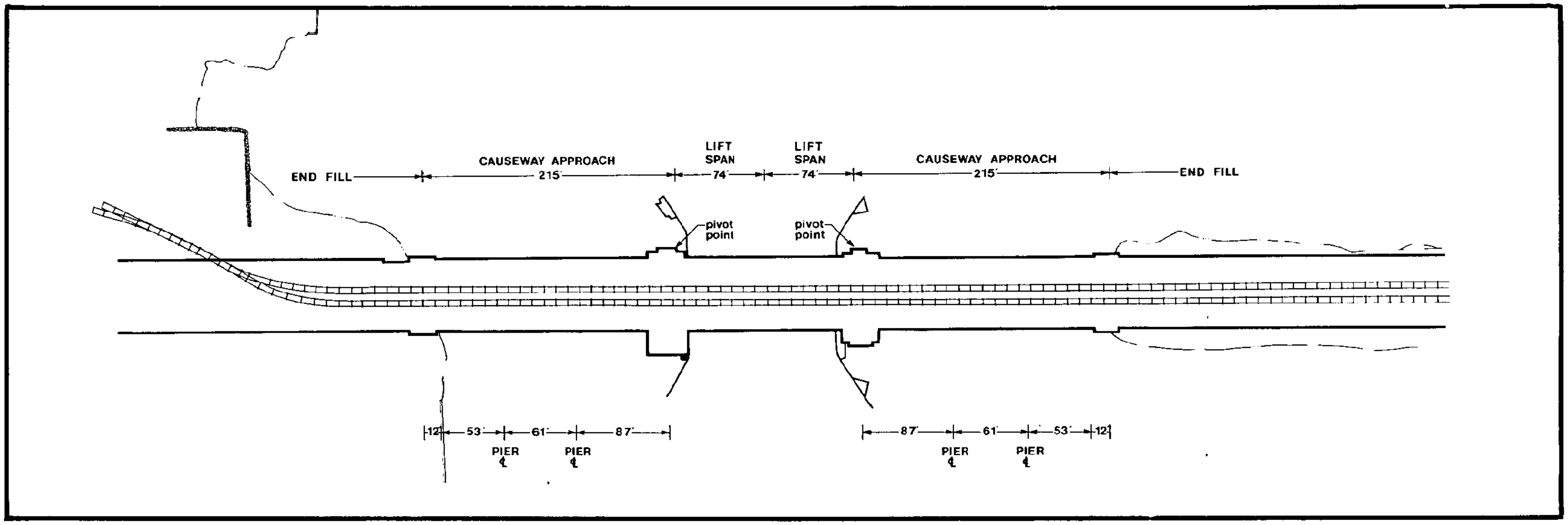


Figure 8: Tomlinson Bridge--Basic Sections. A combination of fill, 215-foot symmetrical approaches and twin 89-foot long double leaf bascule spans bridge the 1,000-foot wide Quinnipiac River.

Table 8: Key Tomlinson Bridge Elements.
A tight knit pile pattern suggests that the substructure should easily accommodate increased demands generated by heavier multi-car trains. Superstructure elements, described here, would require reinforcement.

THE TOMLINSON BRIDGE

Element	Description
general description	three fixed spans at each approach to a double leaf bascule span at mid-channel.
approaches	variable depth steel girders designed to accommodate a 24-foot hung span at the center of each approach. . structural concrete deck slab supporting a concrete ballast in which railroad ties on tracks are embedded. . asphalt overlay replacing original creosoted paving blocks. . each of the four interior girders supports the wheel loads from one train on a two-track system.
bascules	. double leaf bascule at mid-channel consists of four variable depth girders supporting trussed and/or solid floor beams with an open steel grating floor system. . grating supported by steel stringers and a transverse channel support system. . two interior bascule girders support 80 percent of the rail loading from a two-track rail system.

each weekday in the mid-1950's before completion of the parallel high level Connecticut Turnpike crossing (Figure 9).(21) Current 1982 weekday traffic volumes range between only 9,000 and 10,000 vehicles while the adjacent six lane Quinnipiac River Bridge (I-95) carries about 90,000 vehicles a day. Peak hour Quinnipiac Bridge congestion and limited east-west travel options once again focus attention on U.S. 1 (Forbes Avenue) as an alternative harbor crossing.(22)

Collisions, Repairs and Regulation

Recent (1973-1979) barge collisions with the Tomlinson Bridge have resulted in (Table 9)

- a new fender system (Table 10). Gear mechanisms are now fully protected against all but head-on (bow first) hits.

- improvements which permit bascule leafs to reach an almost perpendicular position when raised. Original counterweight construction failed to meet U.S. Army Corps of Engineers permit guidelines. Neither counterweight design nor density allowed the bascules to be raised to a position of more than 70 degrees relative to the water. Limited vertical clearance effectively reduced channel width. Large vessels could not make use of the full 120-foot channel. Similarly, fender systems could not fully protect lift spans.

Three-year old Coast Guard regulations intended to protect the Bridge recognize navigation problems.(23) Regulations limit movement of large vessels relative to tide and wind, specify towing

(21) Wilbur Smith and Associates, A Comprehensive Traffic Improvement Plan for the City of New Haven (New Haven: WSA, 1954).

(22) "An I-95 Operations Study" now in progress via the Regional Planning Agency explores both near-term traffic management strategies and longer term, more costly investment options.

(23) Regulations applicable to barges with a freeboard (height of side between the water line and deck or gunwale, the uppermost edge of the vessel side) greater than ten feet prohibit: (1) transit except during the period from one hour to five hours after a high water slack (after the ebb tide when incoming current peaks and outgoing vessels encounter a head current); (2) movement when the wind speed at the bridge (continued)

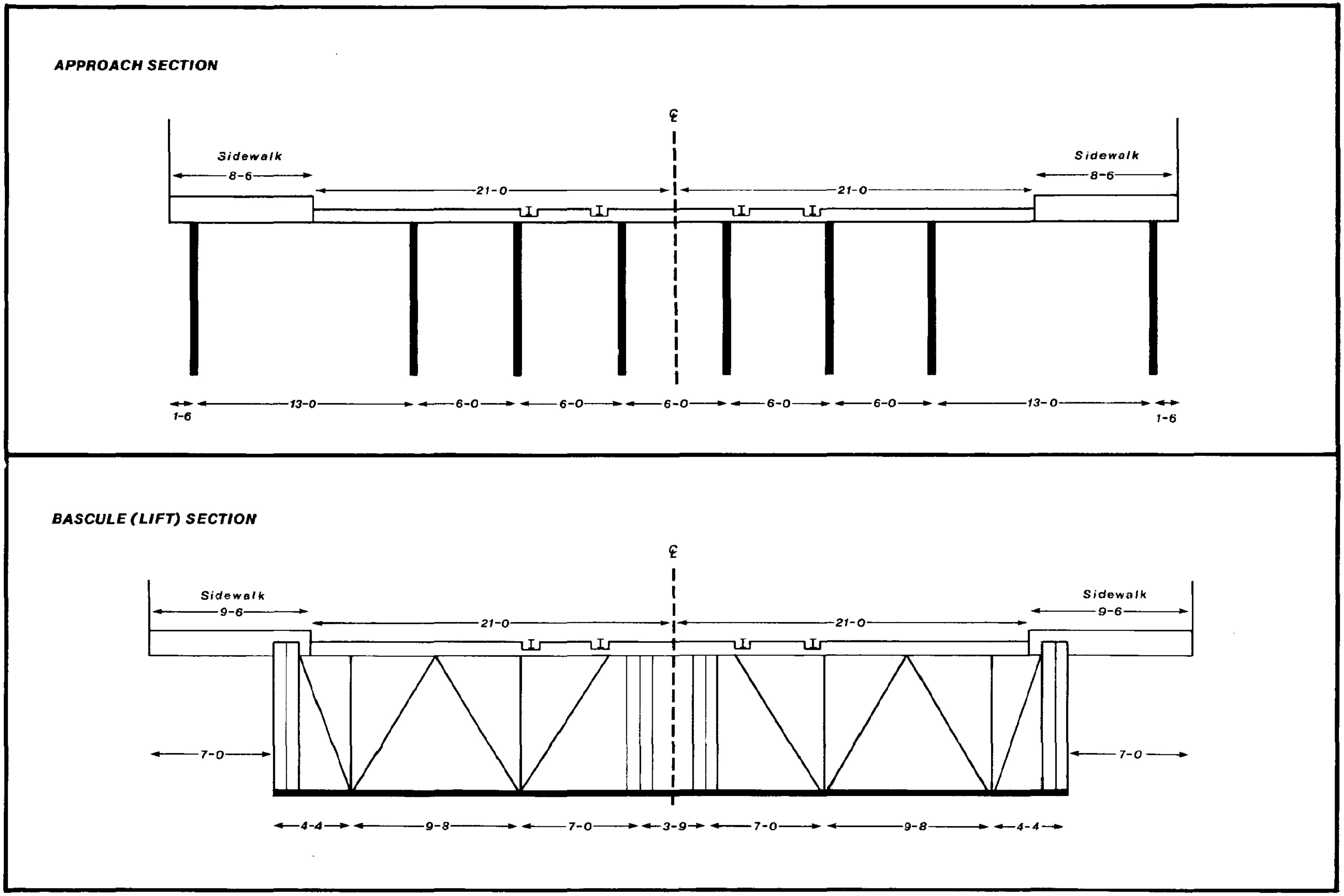


Figure 9: Tomlinson Bridge Roadway Section. A 42-foot roadway carries four lanes across the Tomlinson Bridge (not to scale).

MAJOR COLLISIONS			
Date (time)	**Barge**	**Circumstances**	**Collision**
5-17-72 (----)	Atlantic Cement B Craft	towed stern first by Diana Moran and tailed by Devan.	king post (cargo boom) contacted east abutment.
11-9-75 (3:40 PM)	Atlantic Cement B Craft	towed stern first by Diana Moran. Tug favored east side due to winds but barge "set" to west. 23' high freeboard over-road fender system. Wind SSE at 5-10 knots.	port bow contacted girder supports of northwest bascule leaf.
8-1-76 (3:45 PM)	Atlantic Cement B Craft	towed stern first by Diana Moran. 15-20 knot wind at 15 minutes before high tide (strong current).	chock (fitting for towline) hit girder on north side of east leaf.
8-30-76 (2:20 PM)	Hygrade 42 (oil)	towed by tug Port Jefferson, barge rubbed east side of I-95 fender system, tug over-compensated by swinging west moving diagonally across the channel. 15-20 knot NW wind and flood current.	south side of west bascule leaf.
6-15-79 (4:00 PM)	Atlantic Cement B Craft	towed stern first by Robin 6 due to Moran strike, tailed by New London. Barge ricocheted to west after striking east fender system. Unorthodox "make-up" by operator unfamiliar with local waters.	rammed southwest corner of bridge just above gears after over-riding fender system.

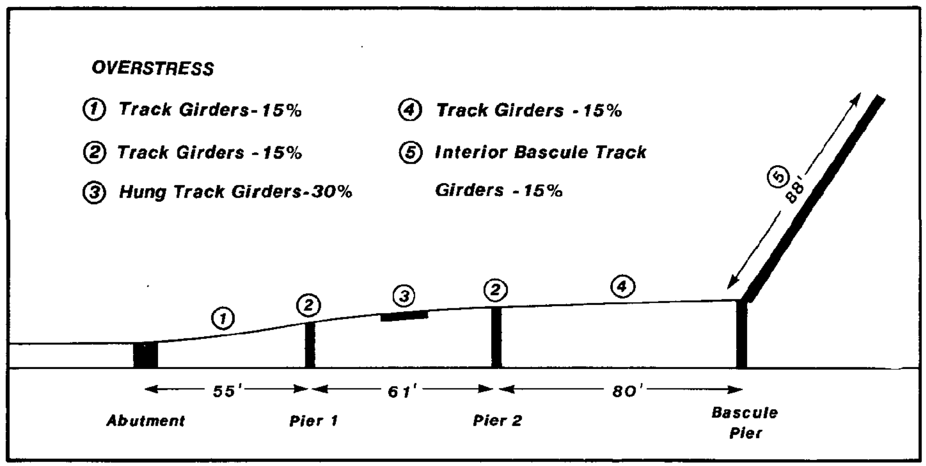
Table 9: Recent Tomlinson Bridge Barge Collisions. Five major collisions in the 1970's left the bridge out of service for extended periods.

Table 10: Major Tomlinson Bridge Repairs. Three major Connecticut Department of Transportation projects since 1973 have addressed barge damage and urgent structural repairs.

MAJOR REPAIRS
1973 — 1984

Date (Project No.)	Major Elements	Cost
Repairs		
12-73 thru 8-77 (92-160) (92-204)	. remove and replace lift machinery. . major replacement to northeast bascule girder and bascule span rehabilitation . raise leafs to 78° relative to roadway and 89° relative to water.	$ 2,302,000
9-77 thru 11-77 (92-245)	. install energy absorbing fender system.	$ 593,000
7-83 -- 5-84	. replace SW counterweight trunion and repair deterioration in other countweweights.	$ 350,000+
STATE DEFINED NEAR-TERM NEEDS	. settlement in one approach span . deteriorated steel in counterweight pit and deteriorated support columns.	$ 1,000,000+

Figure 11: Tomlinson Bridge--Points of Overstress. Multi-car trains composed of 263,000 pound cars would overstress the symmetrical Tomlinson Bridge at twelve key points. Track girders in approach spans and the interior bascule girders would be overstressed.



methods and restrict departures from the Mill River to daylight hours. No collisions have occurred since the advent of tighter Coast Guard control.

Structural Problems

Original design, use and deterioration present both apparent and latent problems which shape investment decisions.

Observed Problems:

Visual inspection suggests several major failures attributable to design and use rather than to materials.[(24)] Key problems include

- major distress in the east abutment. The abutment face has cracked and the northeast wing-wall has rotated several inches (out of plumb) (Figure 10A). A shear crack in the abutment face extending to the water line suggests that both rotation and the crack are due to underwater settlement of piers. A similar shear in the abutment face is evident where the southeast wing-wall has rotated and "pulled" the approach retaining wall with it--at the point where the southeast retaining wall joins the east end of the east abutment (Figures 10B and C).

- some failure in the west abutment. A shear crack at the north end of the west abutment (10D) and, as above, rotation in the wing-wall (10E) suggest loss of support. Footings and/or piles have failed.

- failure of Pier 2 on the west approach. Cracks are evident on both the east

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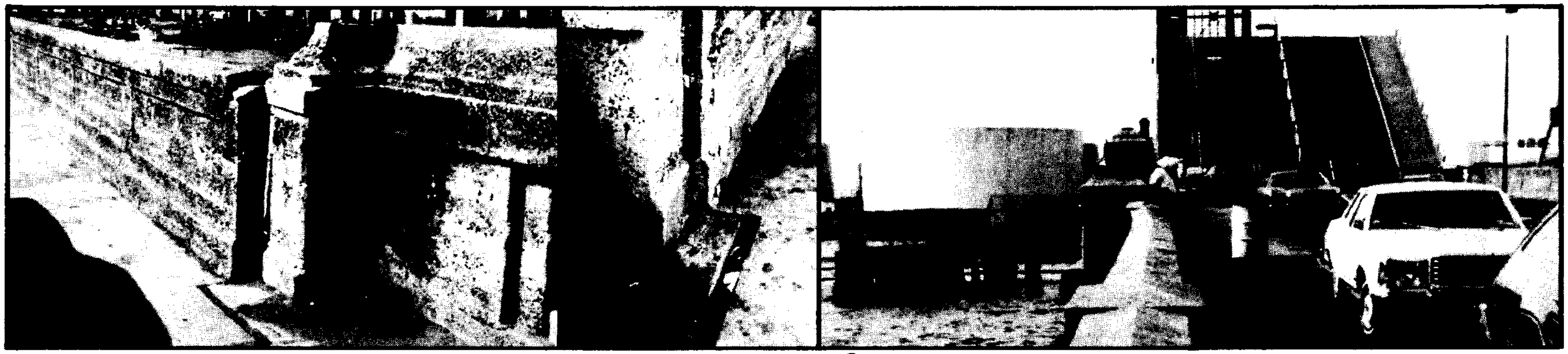
(23) (Cont.) exceeds 20 knots or 23 miles per hour; and (3) towing stern first on a howser (relatively difficult to control). In addition: (1) vessels with a beam (width at maximum point) of more that 50 feet must be pushed under the bridge; (2) a lookout is required under certain conditions; and (3) barges departing the Mill River must leave in daylight, be pushed bow first and have a second tug standing by to assist at the bow. See 33 CFR Part 128 in Federal Register Volume 46, No. 20, November 16, 1981.

(24) Stone and underwater (unexposed) piers should have virtually indefinite lives.



A B C

D E F G

Figure 10: Substructure Problems. Major signs of distress include rotation of the northeast wingwall at the east abutment (A); displacement of the southeast wingwall (east abutment) (B and C); shear in west abutment (D); rotation of northwest wingwall (E); and shear cracks through both faces of pier 2 on the east approach (F and G).

and west face of the pier--they suggest foundation and/or pile failure due to loads (Figures 10F and G). Underwater inspection will probably reveal a crack in the concrete below the stonework. Significantly, cracks appear between girders which support rails.

Distress is limited. Positive indications include the absence of settlement in approach piers other than Pier 2, no visual distress in the bascule piers and generally good condition of major steel girders encased in gunite.(25) Major substructure units including the approaches appear salvageable.

Latent Problems:

Rehabilitation efforts through the 1970's accomplished only those repairs necessary to restore and/or maintain service. Damage by barges, mechanical problems with the lift mechanism and pockets of deterioration were addressed. Incremental responses failed to address major long-term rehabilitation needs basic to highway and rail performance. A comprehensive rehabilitation program which minimizes periodic service disruptions must address known substructure failures (above) and the condition of key elements including

- the live load anchorage and supports (Figure 6). Live load anchorages encased in concrete within bascule piers are not subject to visual inspection. The condition of steel embedded in concrete below the pit floor is of major importance. Anchorages accept and resist the load applied to the bascules in a closed position--they set on bearing elements (assembly) of the live load support. Flaws in the live load anchorage can have a major impact on the economics of rehabilitation.

- main trunnions (Figure 6). A collar, pin and support system permit bascules to rotate. Wear must be addressed.

- the counterweight system. Concerns include counterweight trunnion bearings, existing bronze bushings, counterweight truss hangers, and the steel truss support system embedded in the counterweight.

- deteriorated steel in the counterweight pit and deteriorated support columns.

(25) Recently exposed steel appears in good condition--suggesting that gunite has been effective.

Design Limits:

Original (1917) design decisions will impact rehabilitation costs if the facility is to accomodate contemporary rail equipment. Decisions reflected in original plans and specifications

- assumed high performance steel. Design plans are premised upon steel with a flexural tensile strength of 24,000 pounds per square inch (the ability to re-assume shape without damage). Design plans premised upon American Railway Engineering Association (AREA) codes of the 1920's generally assumed a 16,000 pound per square inch allowable stress standard. Only exacting quality control could have gained a 24,000 pound per square inch capability at the time. A more conservative assumption would have produced a more conservative design offering greater long-term flexibility. Less costly measures to accomodate heavier cars might have been possible. Contemporary designs intended to accomodate loads of 24,000 pounds per square inch would select steel with an ultimate stress of at least 60,000 pounds per square inch.

- understate live load impact attributable to rail cars. Thirty-three foot (33') World War I era rail freight cars established "design" vehicles. Associated impact estimates (dynamic force) reflected in specifications were significantly below those then in common use.[26]

Heavier Cars:

Limited design margins reinforce the Connecticut Department of Transportation's decision to adhere to a 200,000 pound maximum weight for rail cars.[27] Comtemporary 263,000 pound cars in multi-

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(26) City of New Haven, Department of Public Works, Specifications, Forms of Contracts and Bonds for Tomlinson Bridge Over the Quinnipiac River at Forbes Avenue: Steel Contract prepared by Earnest W. Wiggin and Strauss Bascule Bridge Company, 1922. Impact percentages or allowances are inconsistent with those of the 1915 Manual of the American Railway Engineering Association despite acknowledgment of the AREA manual.

(27) A quick check of existing sections by Seelye, Stevenson, Value and Knecht. Increased loads associated with heavier equipment broadly suggest whether stresses in steel remain within original 24,000 psi design values.

car units would (Figure 11)[28]

- overstress track girders by about 15 percent in key areas of the fixed approach span (Appendix C).

- overstress track girders in the catilever section between Pier 1 and the beginning of the hung span leading to Pier 2 by about 15 percent. A maximum stress develops in the cantilever or negative moment area.

- be marginally acceptable at Pier 2. Stress in the negative moment area (cantilever) of the track girders appears to be less than the allowable original design stress of 24,000 pounds per square inch.

- overstress track girders in fixed approach span three by about 15 percent in the maximum positive moment area.

- overstress the 23 foot, 10 inch long hung track girders in the center span between approach piers by about 30 percent.

- overstress interior bascule girders supporting the double tracks by about 15 percent.

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(28) A limited design check by Seelye, Stevenson, Value and Knecht to determine whether the existing structure can support heavier car loadings. A limited stress check of main members: (1) adopted design parameters which included the original (assumed) tensile design stress of 24,000 psi although, as noted in the text, a tenuous assumption; (2) drew impact factors from the current AREA code for diesel engines; and (3) used gross sections (not net sections) to check support capabilities of the main track girders. The design check proceeded exclusive of fatigue considerations. Calculations appear in Appendix C.

5. ALTERNATIVES

Major new construction in the densely developed harbor area is expensive and disruptive. Opportunities to use existing facilities, minimize investment and effect joint highway--rail use recommend rehabilitation of the Tomlinson Bridge. An improved bridge and approaches can accomodate major freight car traffic, offer railroads an attractive operating environment and allow area shippers to compete effectively. Good service can be offered to customers along Forbes Avenue, to New Haven Terminal's current Waterfront Street facility and to the Terminal's new site north of Forbes Avenue.

New River Crossings

Single track rail crossings within 1,000 feet of the Tomlinson Bridge confront similar operating, right-of-way and construction constraints (Figure 12).[29] Limited advantages inherent in an exclusive rail right-of-way are largely offset by huge capital costs and the necessity of at least one at-grade crossing of Forbes Avenue regardless of alignment. Major investment necessary to meet highway needs can be meshed with rail requirements.

Exclusive Alignment--Benefits are Limited Here:

Speed

Benefits of high speed movement on an exclusive rail right-of-way are largely offset in the harbor area where a 10 mile per hour switching speed generally prevails and distances are short. A multi-car train crossing the Tomlinson Bridge at 10 miles per hour takes only two to three minutes to cover the 1,600 feet between Belle Dock and Water Street (Table 11).[30]

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(29) Options advanced over the past ten years are collated and addressed in: Connecticut Department of Transportation, The Tomlinson Bridge Rail Link (Wethersfield: ConnDOT, 1980).

(30) For example, from the time an eastbound engine enters Forbes Avenue to the time the last car moves from Forbes Avenue on to Water Street. One car operations moving slowly against vehicular traffic take almost four minutes to cover the same distance. Single car "consists" shuttling back and forth would inhibit vehicular movement. Multi-car trains which periodically make exclusive use of the bridge in off-peak hours are compatible with the traffic flow needs. Traffic control plans which restrict vehicular access would have to be devised.

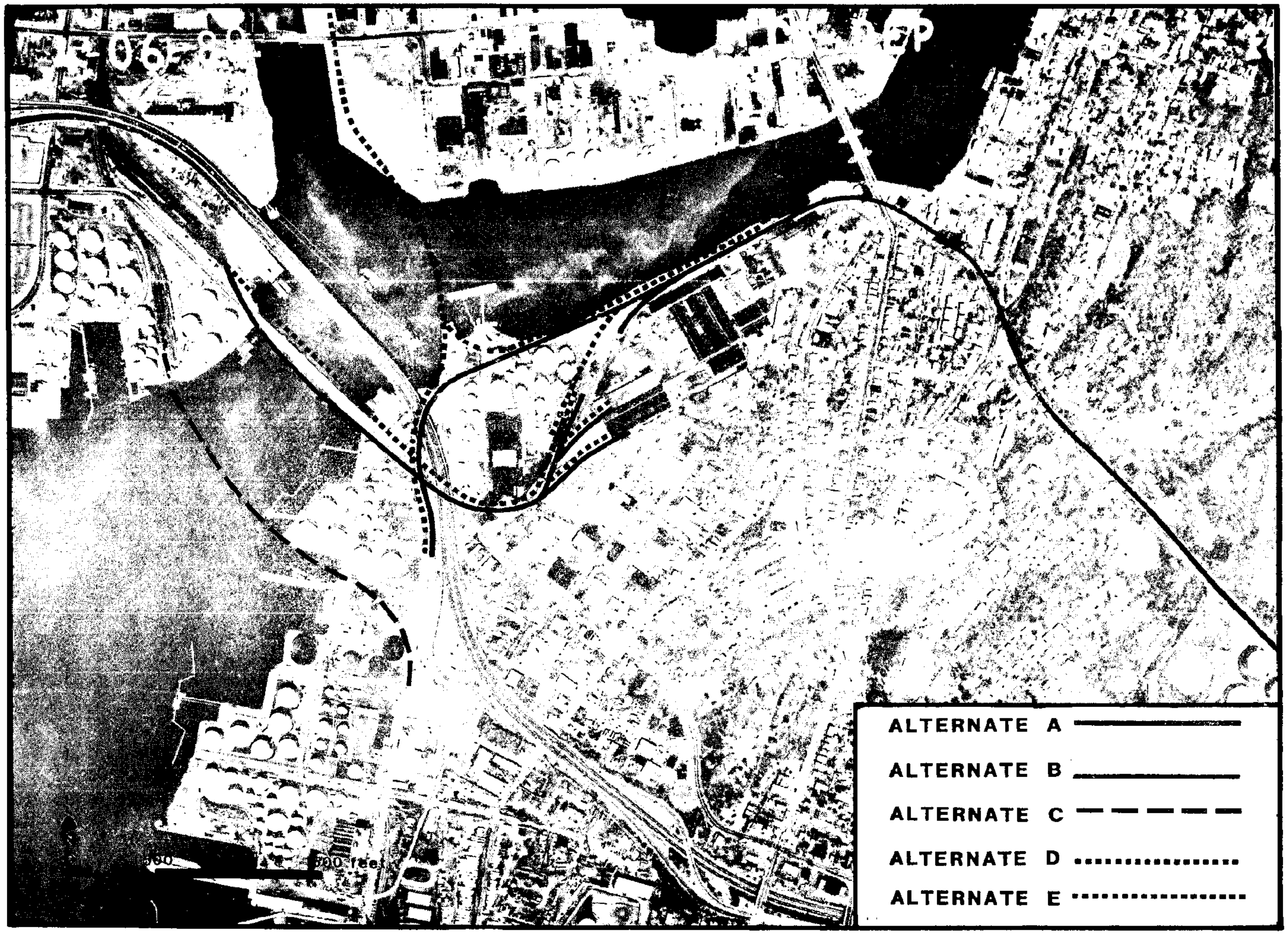


Figure 12: Rail Service Options. Options advanced over the past 10 years include: (a) new structure immediately south of the Tomlinson Bridge; (b) an inland approach leaving the Amtrak mainline in East Haven; (c) new structure well south of the existing bridge; (d) service over the Manufacturers Railroad along the east bank of the Mill River; and (e) a "rail only" alignment immediately north of the existing Tomlinson Bridge. Upgrading the existing bridge and improving approaches can create new rail capacity faster, at less cost and with less disruption than any of the five "options."

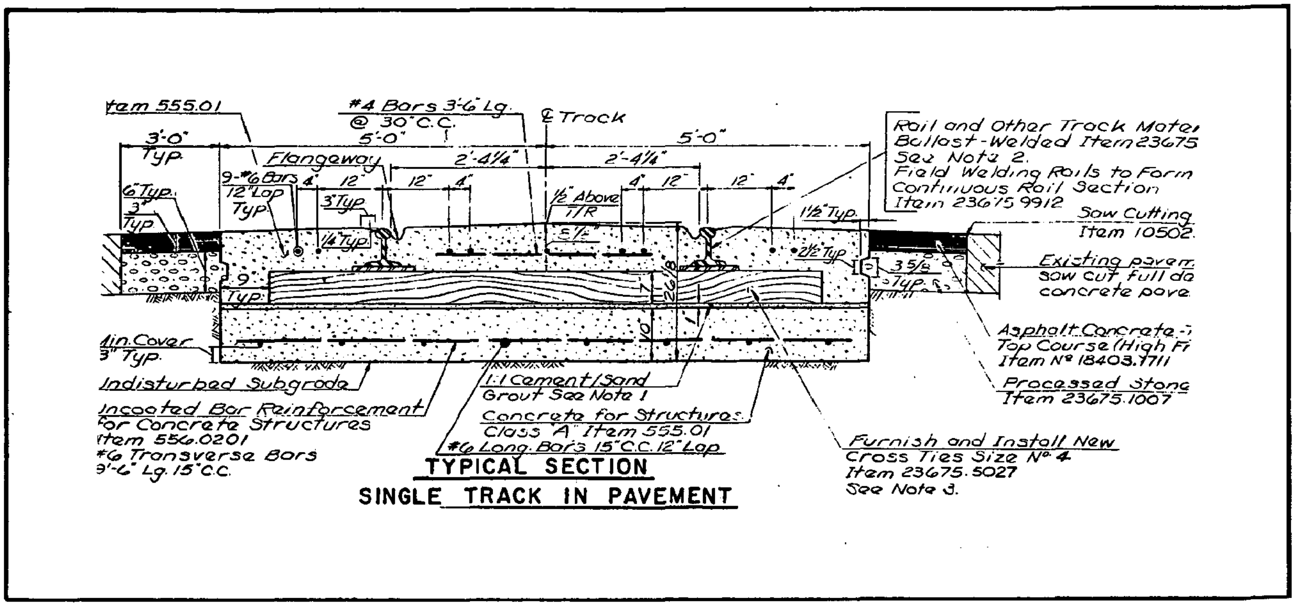


Figure 13: Typical Track in Pavement. Careful installation can provide a good environment for track embedded in Forbes Avenue and Waterfront Street. (Design per Seeyle, Stevenson, Value and Knecht as installed along the Brooklyn waterfront.)

Table 11: Crossing the Tomlinson Bridge. A multi-car train will take only three to four minutes to travel the 1,600 foot distance between Belle Dock and Water Street. (Illustrated with 41.6 foot coupled tank cars and a 44.7 foot long SW1500 engine.)

TIME TO CROSS BRIDGE (MINUTES)

Cars Excluding Engine	Speed (mph)		
	5	7.5	10
1	3.8	2.6	1.9
6	4.3	2.9	2.2
8	4.5	3.0	2.3
10	4.7	3.1	2.3
12	4.9	3.2	2.4
14	5.0	3.4	2.5
16	5.3	3.5	2.6

Track Maintenance

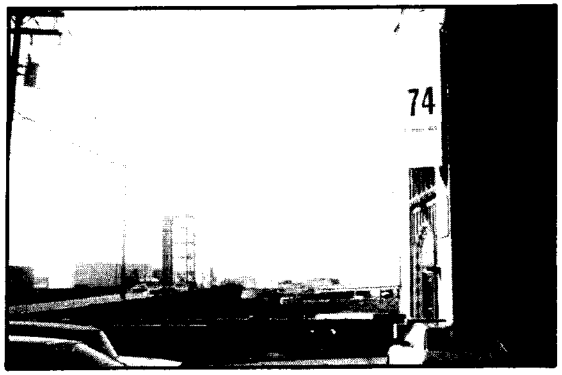
Properly embedded rail (150 pounds or better) will offset maintenance costs inherent in a mixed use environment. Train related rail wear is a function of traffic volumes, speed, axle leadings, curvature, grade, ballast and surface corrosion (low density lines). Rail demand and steel-on-steel friction control rail life to a far greater extent than auto and truck movement. Modern installations techniques can provide a good environment for track embedded in Forbes Avenue (Figure 13).

Alignment

New river crossings will be disruptive. Even a new span immediately north of the existing facility (Alternative E) will come perilously close to the historic Yale Boat House and clearly interfere with parking arrangements (Figure 14). More significant departures from the existing alignment will:

- largely preempt redevelopment of Conrail's four acre west shore switching yard north of the Wyatt Fuel Company's main facility; require a long, relatively costly clear span to maintain an unobstructed channel; limit flexibility at Gulf Oil's east shore property; and require a reverse movement to serve the Quinnipiac River Industrial Park (Alternative C).

- offer only a single track service north of the Quinnipiac River if an approach provided by the old Manufacturer's Railroad were employed. Narrow right-of-way limits operating flexibility. Light rail and poor track condition would require immediate replacement of 3,600 feet of rail between Chapel Street and Alton Street; an at-grade crossing of Chapel Street would be necessary in contrast to the grade separation on the Belle Dock spur; right-of-way would necessarily infringe upon recreational facilities at Quinnipiac Park; and the alignment would make shore front access difficult to maintain at both Texaco and Mobil properties. Limited switching capabilities at the main line now rule out a multi-car movement via the east shore of the Mill Rover. Switching arrangements require trains moving south on the main line from the Cedar Hill Yards to reverse on to the East Street spur, move north to the short Rockware spur (formerly the Federal Paperboard Company) and then reverse again



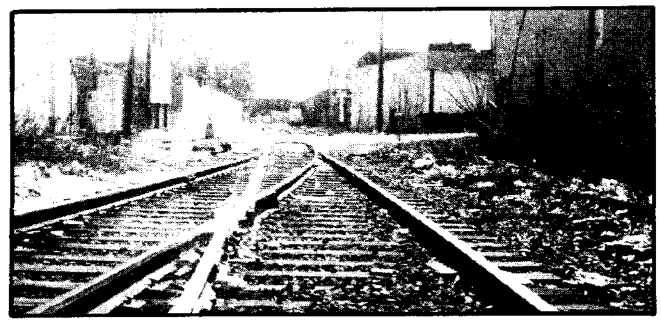
1

NORTH OF THE TOMLINSON BRIDGE

A new span immediately north of the Tomlinson Bridge would come perilously close to the historic Yale Boat House.(1)

EAST STREET SPUR

Track, ties and ballast along the East Street spur are adequate for slow speed switching operations. Here immediately north (2) and south (3) of Grand Street and joining the main line at the left (4).



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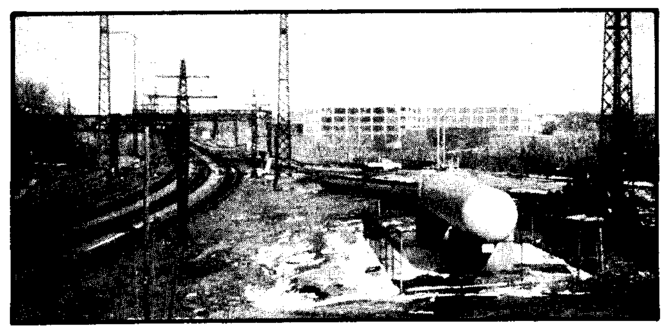

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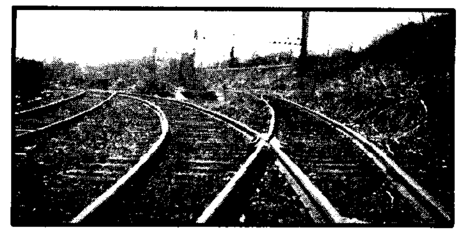
Figure 14: Facilities and the Environment.

MANUFACTURERS SPUR

A narrow right-of-way (5 just north of Grand Street) limits flexibility. Poor track and roadbed require immediate attention (6, 7, 8 and 9) in all areas except north of Alton Street (10) where New Haven accomplished reconstruction for the Federal Paperboard (Rockware) project. A "reverse movement" from the East Street spur (at right 11) to the manufacturers spur (at left 11) occurs on a short 225 foot piece of Rockware spur (12). New alignment would sever Quinnipiac Park from the river (13 looking due south from the spur across Chapel Street).

9

10



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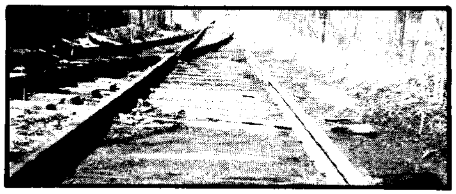

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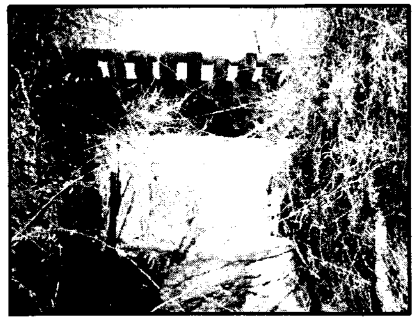
Figure 14 (Cont.): Facilities and the Environment.

14



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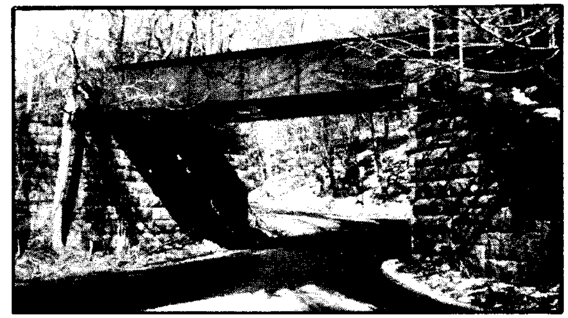

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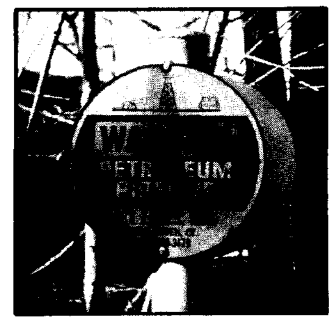
AN INLAND APPROACH

An abandoned three mile rail right-of-way leaves the Amtrak mainline just behind New Haven Terminal's East Haven Tank Farm (14), parallels Warwick Street (15) and crosses Lenox Street (16) before turning north (17) and away from the harbor. Long distance petroleum lines now occupy the right-of-way (18). The right-of-way rises 50 feet above the Quinnipiac River at Lenox Street (19 looking down from the former rail facility). New rail structure extending over Ferry Street to the former U.S. Steel site (20 from the Ferry Street Bridge) would run counter to city policies which have helped create Brewery Square (21 and 22) and new parkland along the river (23 and 24).



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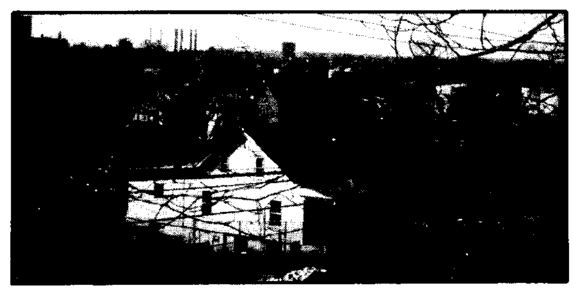

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Figure 14 (Cont.): Facilities and the Environment.

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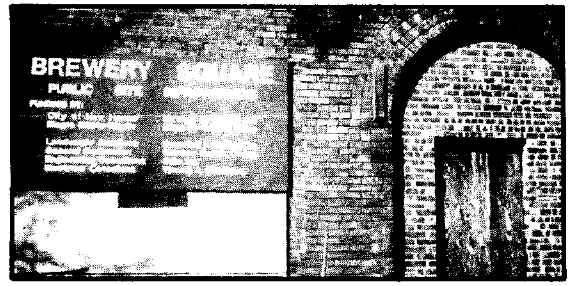

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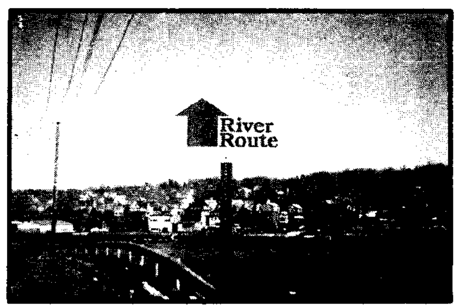

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Figure 14 (Cont.): Facilities and the Environment.

on to the River Street spur--adding 10 minutes to a one way run (Figure 15).(31) The short (225 foot long) Rockware spur can accomodate only an engine and four 45-foot coupled cars. Long "consists" cannot be moved to the harbor without extensive realignment and/or structure in view of embankments immediately south of the main line (Alternative D).

An Inland Approach

The prospect of inland access to the harbor offers relief from navigational constraints and high cost "over the water" construction. A former three mile spur linking the Amtrak main line and old Fair Haven industrial areas provides an interesting, but ultimately disappointing, alternative to a Quinnipiac River crossing. An abandoned inland right-of-way now accomodating long distance petroleum lines (Jet Lines) leaves the main line immediately behind the New Haven Terminal's East Haven tank farm and extends west to and under Quinnipiac Avenue before turning north or away from key harbor areas.

Inland service would:

- eliminate economies stemming from joint use of west shore facilities. One-way movement from the Cedar Hill Yards to Water Street (the east shore) would require about 20 minutes and serve only east shore destinations (Figure 16). Opportunities to share west shore maintenance and capital costs would similarly be lost. Only an extremely high Cedar Hill to east shore interchange would make major inland investment worthwhile. Meeting needs of moderate-to-low east shore traffic would become relatively expensive.

- need new switching facilities in East Haven wetland areas (Polywog Pond) to avoid a reverse movement on the main line.

- require major unattractive structure in the Grand Street--Quinnipiac area. Structure would leave the spur immediately south of the recently remodeled Jepson School, carry 21 feet above Ferry Street and extend 520 feet south of the Ferry Street Bridge along the river to

(31) Reverse movements totaling 2,800 feet at five miles per hour or six minutes rounded to 10 minutes to reflect switching.

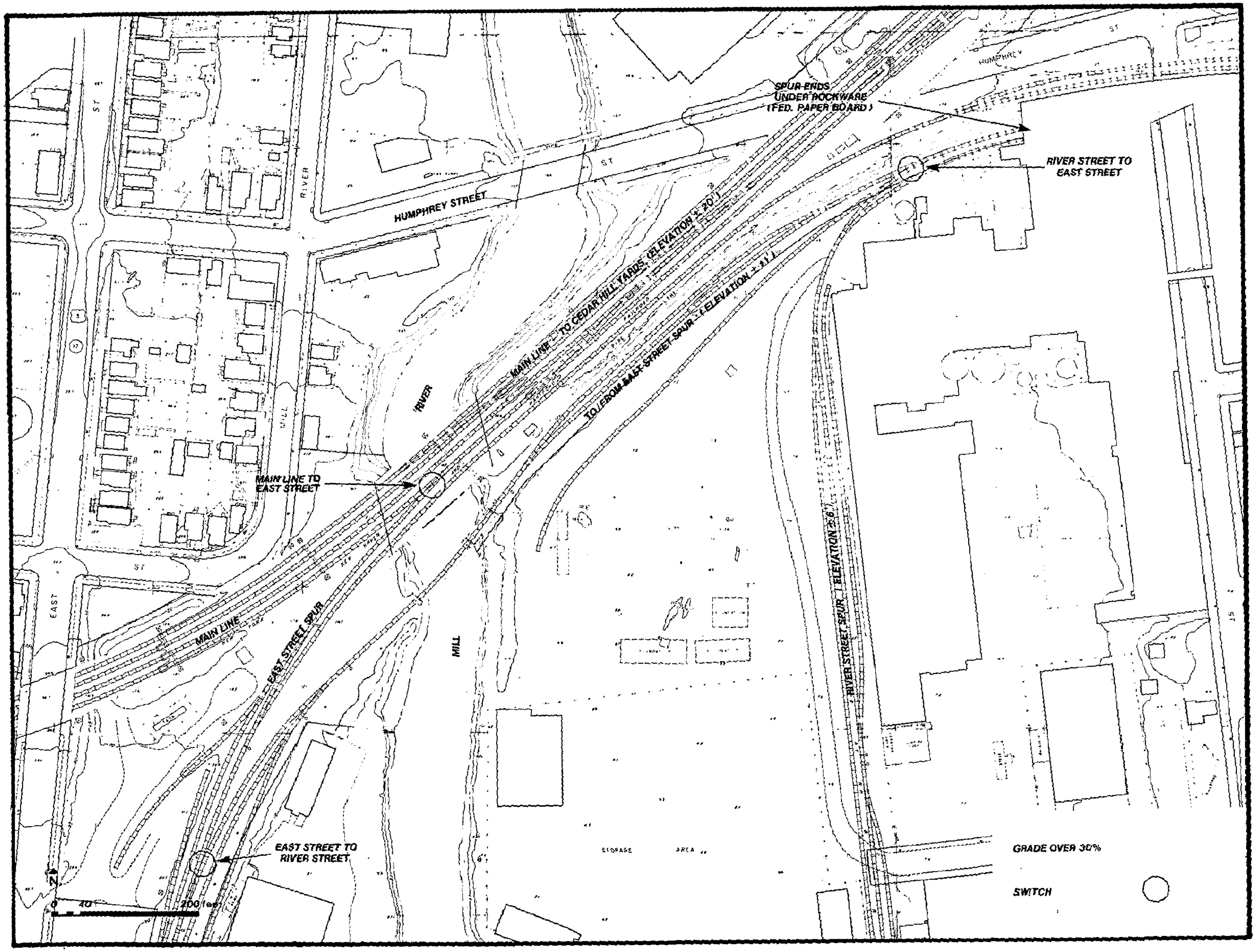
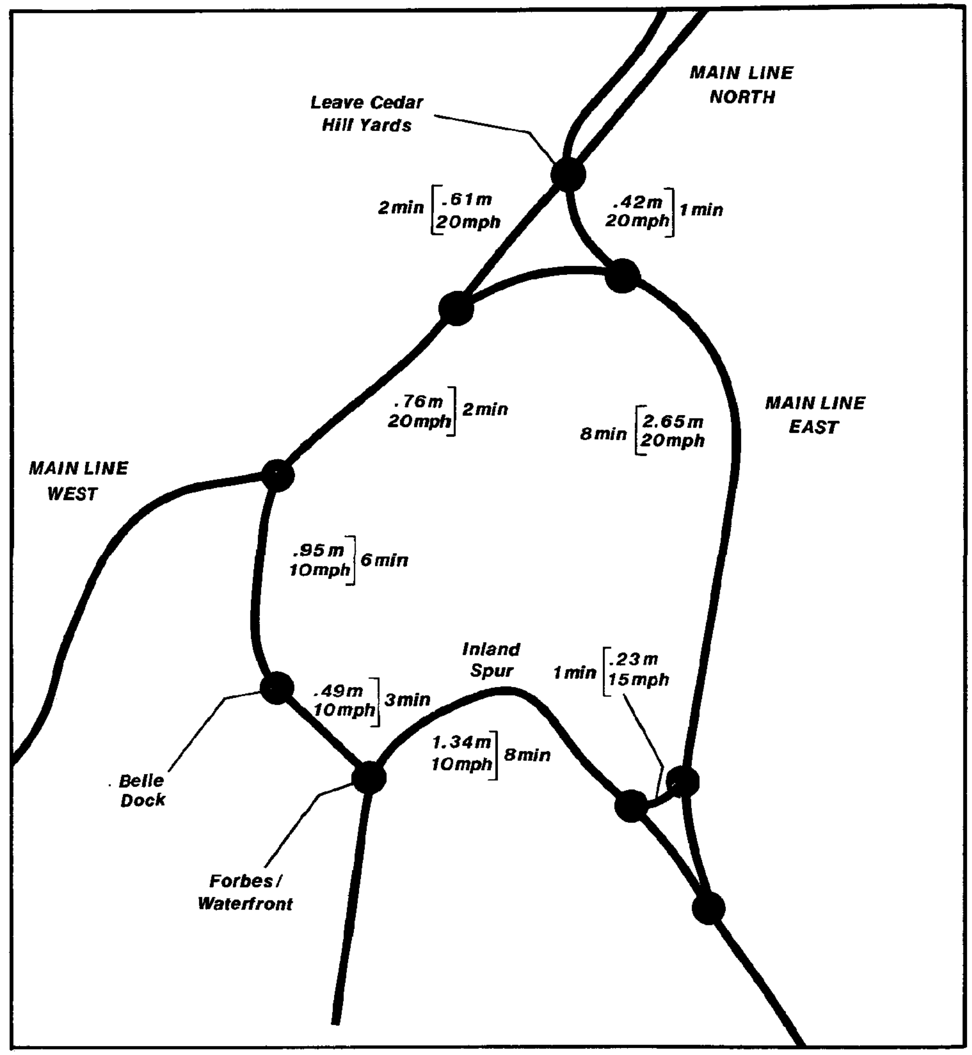


Figure 15: Limitations on the Manufacturers Spur. A reverse movement from the East Street to the Manufacturers spur and short track on the Rockware spur limit the length of trains to about four cars. Difficult grade between the Manufacturers spur and the Main line makes a direct connection costly.

Figure 16: Travel Time. An inland route is not effective for low to moderate volume traffic. Trains from the Cedar Hill Yards would take about 20 minutes to reach east shore Forbes Avenue--Waterfront Street industrial sites. New switching facilities in low wetland areas (Pollywog Pond) would be necessary to avoid a reverse movement on the Main line.



provide a two percent minimally acceptable grade for multi-car "consists" throughout (Figure 17). A 43-foot difference in elevations between the abandoned right-of-way (circa 50 feet at Lenox Street) and river front areas (circa seven feet at Ferry Street) makes structure necessary to present reasonable grades for freight traffic. Structure clearing Ferry Street at 21 feet (offering a minimal 2.5 percent grade for rail) would extend almost 1,600 feet along the river front.(32)

Major structure through low lying river front areas precludes serious attention to an inland route. Long-term efforts in Quinnipiac River shoreline areas between Ferry Street and Grand Avenue are reflected in construction at Brewery Square (Figure 14), a new riverfront park immediately north of Brewery Square and extensive private rehabilitation of adjacent properties. A rail structure would prove disruptive, visually intrusive and inconsistent with long-term development policies

Cost

Ordef of magnitude cost estimates reinforce the desirability of meeting contemporary rail needs via an improved Tomlinson Bridge.

Capital Costs:

High "over the water" construction costs work against new river crossings (Table 12). Options involving long spans (900--1,000 feet) of the Quinnipiac River tend toward the high end of the cost spectrum exclusive of associated right-of-way requirements. Major shorefront right-of-way acquisition (Alternative C) pushes the cost of a new southerly crossing toward the $30 million level. Immediate and extensive rail replacement needs along the Manufacturer's Spur bring costs associated with Alternative D into the $25 million dollar range. In contrast, reinforcing key Tomlinson Bridge structural elements and acquiring limited east shore right-of-way for improved curvature can be accomplished for circa seven million dollars in concert with a sorely needed $10 to $12 million dollar Tomlinson Bridge rehabilitation project. A comprehensive rehabilitation project addressing both rail and highway operating needs should be initiated at an early date.

(32) A 21 foot clearance necessary for an acceptable rail grade versus a circa 14 foot highway (truck) clearance requirement. Extending from elevation 49 on the right-of-way to elevation 21 at the west or south abutment of the Ferry Street Bridge--27 feet over 1,040 feet or a 2.6 percent grade. Another 520 feet of downstream structure is necessary to return to grade at elevation 8.

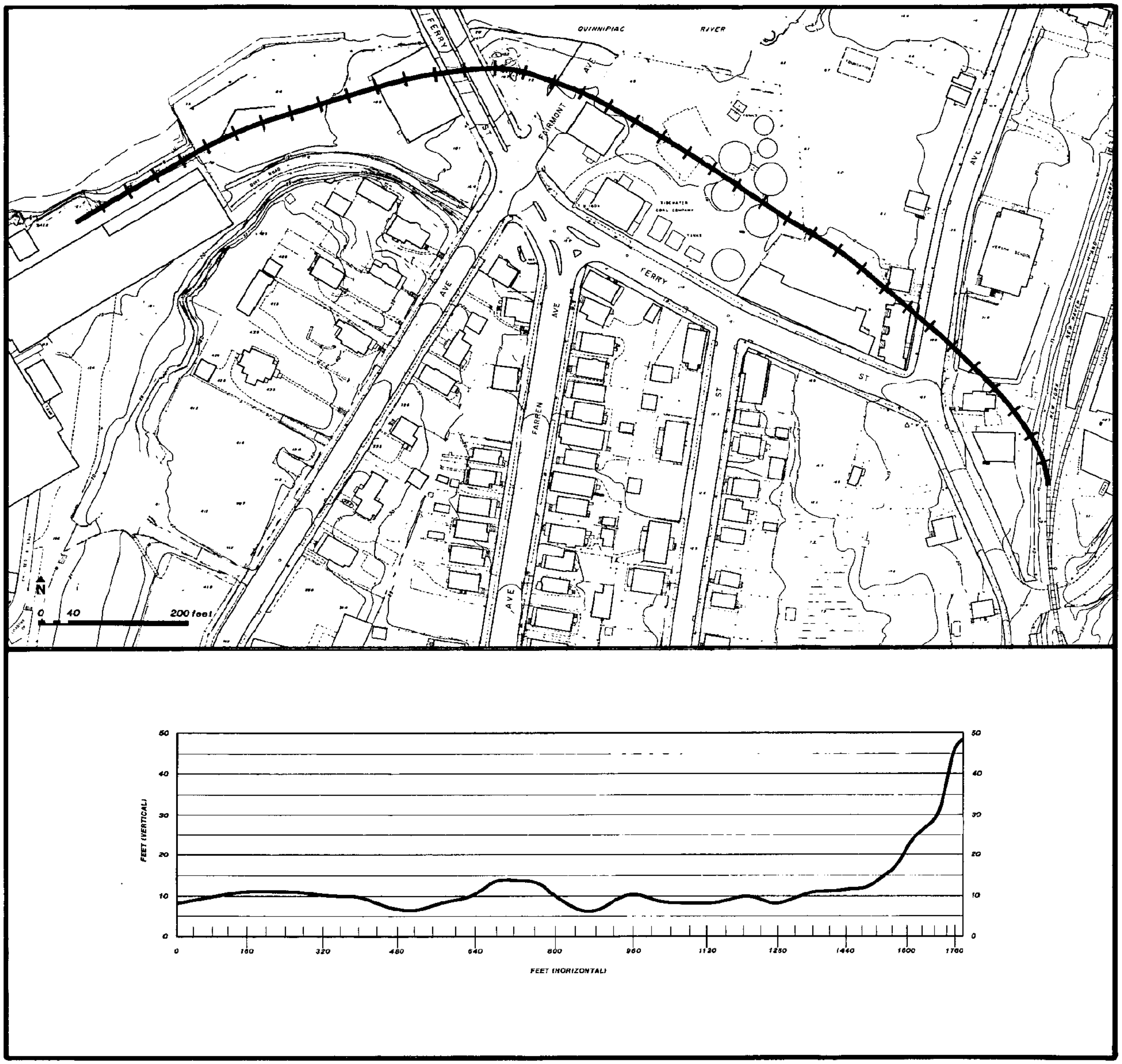


Figure 17: New Structure at Ferry Street. Maintaining a two to 2.5 percent grade for an "inland route" would require almost 1,600 feet of structure in riverfront areas.

One or Two Tracks on the Tomlinson Bridge:

Bridge design now permits separation of each bascule section into independent leafs during maintenance and repair periods. Single track rail service can be maintained while one or opposing leafs are repaired. Current designs now load weight equally on the four identical interior approach girders--each girder absorbs 50 percent of the weight of each track (Figure 9). Dual service on approaches will require strengthening of all four girders versus the center pair associated with single track operations. Bascule sections present a more difficult trade-off. Two interior bascule girders receive 80 percent of the load generated by respective tracks. Introducing a new single track with heavy rail cars will decrease stress on each of the interior bascule girders--presenting substantial economies during rehabilitation. Conversely, major new section properties on all bascule elements will be necessary to accomodate a dual track system.

Comprehensive bridge rehabilitation, good maintenance and new stringent navigation rules can minimize, but not eliminate, the risk of substantial service loss. Only two tracks offer insurance against a major service interruption. Early, in-depth design can establish marginal costs inherent in a two track option.

Long-Term Costs:

New capabilities can make rail more attractive to both shippers and railroads (Table 13). Current "one at a time" movement over the Tomlinson Bridge incurs high direct costs (labor and mechanical). Long-term "bottom line" costs inherent in alternate rail service schemes are shaped by a mix of capital, maintenance and operating requirements (Appendix D). Multi-car operating economies are significant as east shore loads move from present 600 car levels to circa 2,000 annual car movements. Relative gains fall off beyond the 2,000 car level--largely because more than one daily run from the Cedar Hill Yards to the harbor becomes necessary. Switching engines operating between the yards and the harbor can draw about twenty trailing cars. Current west shore demand at 3,400 cars per year and east shore 2,000 car traffic levels exceed average daily twenty cars single consist capabilities--another run becomes necessary.

CRUDE COST ESTIMATES
Cost in Thousands

Element	Tomlinson Bridge		A		B		C		D		E	
	HEAVY RAIL NEEDS		S/O TOMLINSON		INLAND ROUTE		1000' S/O TOMLINSON		MANUFACTURERS RR		N/O TOMLINSON	
Capital Cost												
bridge over river with causeway	$ --	$5,000	$ 675	$12,938	$ --	$ --	$1,300	$20,750	$ 900	$15,753	$ 750	$13,875
bridge on land			--	--	2,600	3,900	--	--	--	--	--	--
on fill with retaining walls			300	285	--	--	450	428	650	618	300	285
relocate fuel pipeline			--	--	5,300	530	--	--	--	--	--	--
major realignment and new switching			--	--	8,800	1,980	--	--	--	--	--	--
only new or improved rail	3,300	743	3,150	709	--	--	3,150	709	6,775	3,024	2,900	153
subtotal construction		$5,743		$13,932		$6,410		$21,887		$19,395		$14,813
design and construction supervision		1,434		3,483		1,602		5,472		4,843		3,703
right-of-way		54		154		1,528		1,167		367		801
Total Capital Cost		$7,231		$17,569		$9,540		$28,526		$24,581		$19,317

Table 12: Associated Costs. High "over the water" construction costs work against new river crossings. Reinforcing key Tomlinson Bridge elements and improving approach alignment works best if pursued within the context of a comprehensive bridge rehabilitation project. (Source: Appendix D).

Table 13: Operating Costs. New investment can make rail movement more appealing. A mix of maintenance and direct operating expenses shapes unit costs. (Source: Appendix D).

MOVING A CAR FROM CEDAR HILL TO THE EAST SHORE
Maintenance and Operating Cost

Operating Option	Cost Per Car		
	600 CARS PER YEAR	2000 CARS PER YEAR	4000 CARS PER YEAR
Current	$72	$48	$45
heavy rail on Tomlinson	42	15	12
immediately s/o Tomlinson	42	15	12
inland route	55	16	13
1,000 ft s/o Tomlinson	37	13	11
Manufacturers spur	64	19	14
n/o Tomlinson	39	13	11

APPENDIX A
REPRESENTATIVE FREIGHT CARS

Dimensions and profiles of representative equipment are drawn from three sources:

(1) Association of American Railroads, Mechanical Division, The Car and Locomotive Cyclopedia of American Practices (Omaha, Nebraska: Simmons-Boardman, 1980).

(2) Union Tank Car Company, Union Tank Car Book: Nomenclature, Specifications and Information (Chicago: UTC, 1983).

(3) Conrail "Equipment Registry" unpublished, undated.

Sources are appropriately identified.

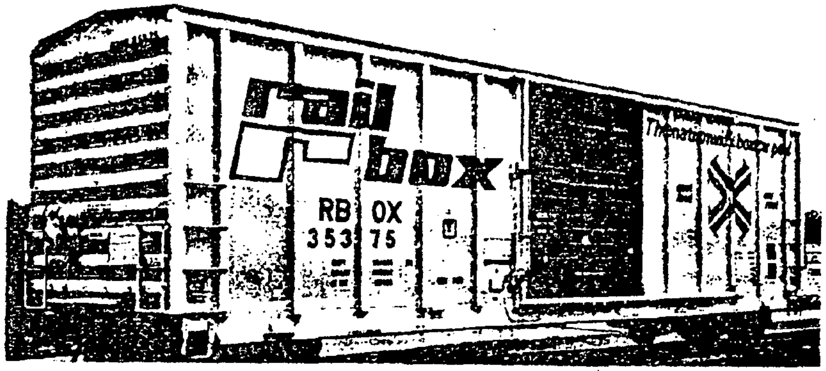
BOX CARS

General Size

Sixty and 86 foot length with 70 and 100 ton capacities introduced in the early 1960's now predominate. Fifty foot 70 and 100 ton cars remain common. General service and equipped for particular commodities. Car interiors are often equipped with load stowing and load restraining devices including movable bulkheads, load dividers and air bags. Wide doors (six through ten feet in width) permit entry by fork lift trucks and other material handling devices.

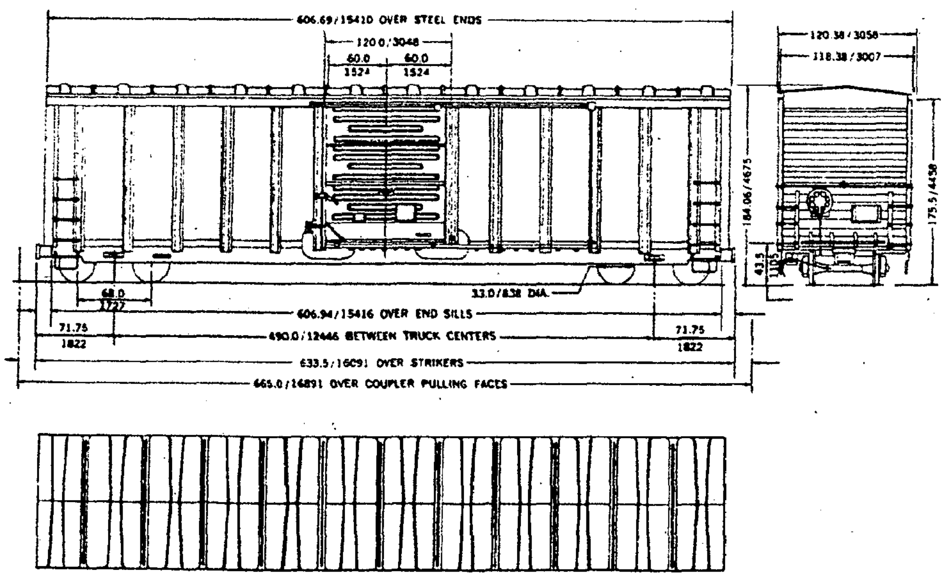
Typical Load

Manufactured goods and hard woods.
Relatively light density goods tend toward 60-foot cars.



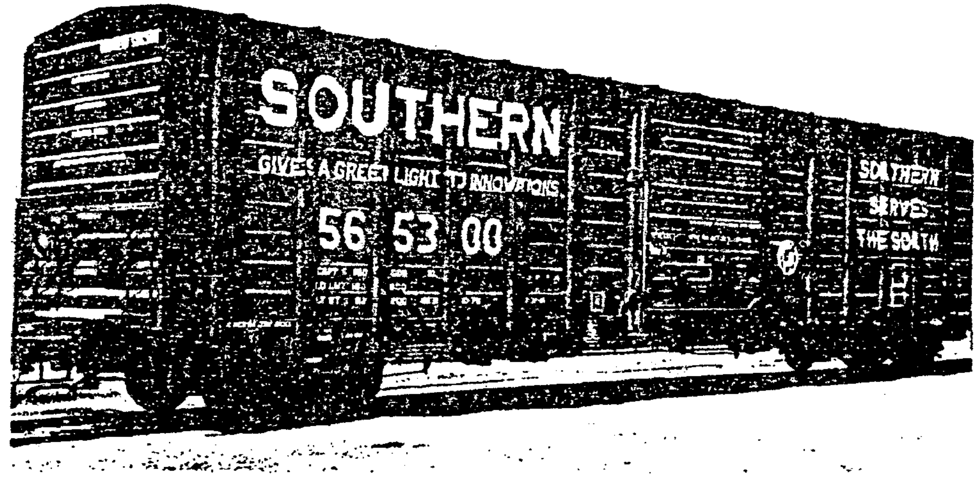
Railbox 70-ton General Purpose Box Car.
Length inside is 50'6". Capacity 154,000 lbs., cubic capacity 5,277 cu. ft. Built with Pullman Standard 10' sliding door, riveted roof, nailable steel floor. Car has a rigid underframe. Plate C clearance. See general arrangement diagram for dimensions. Built by Pullman Standard, 1979.

PULLMAN STANDARD



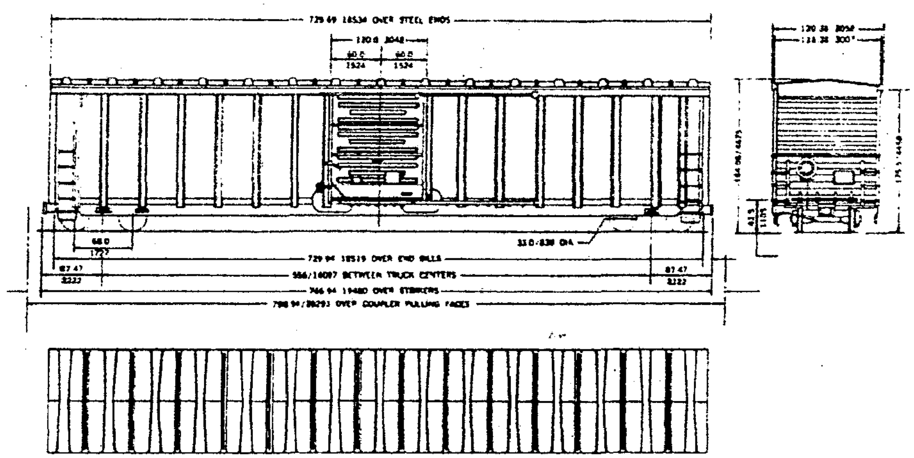
Pullman Standard 70-Ton 50'6" Box Car.

Source 1



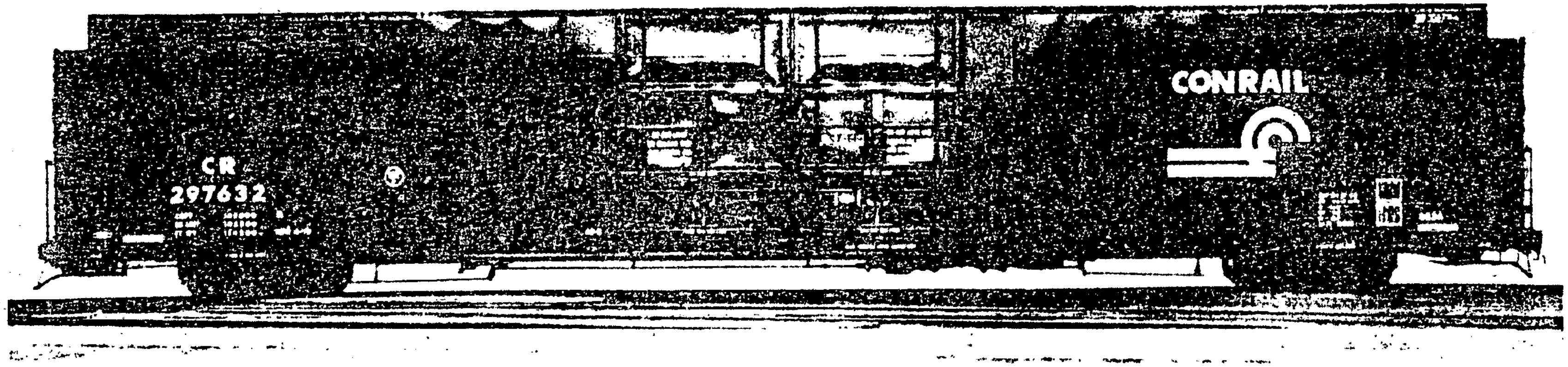
Southern Railway 100-ton General Purpose Box Car.
Length inside is 60'9". Capacity 180,000 lbs., cubic capacity 6448 cu. ft. Built with Pullman Standard 10' sliding door, riveted roof and nailable steel floor. The car is equipped with end-of-car cushioning. Plate C clearance. See general arrangement diagram for dimensions of similar car. Built by Pullman Standard. 1979

PULLMAN STANDARD

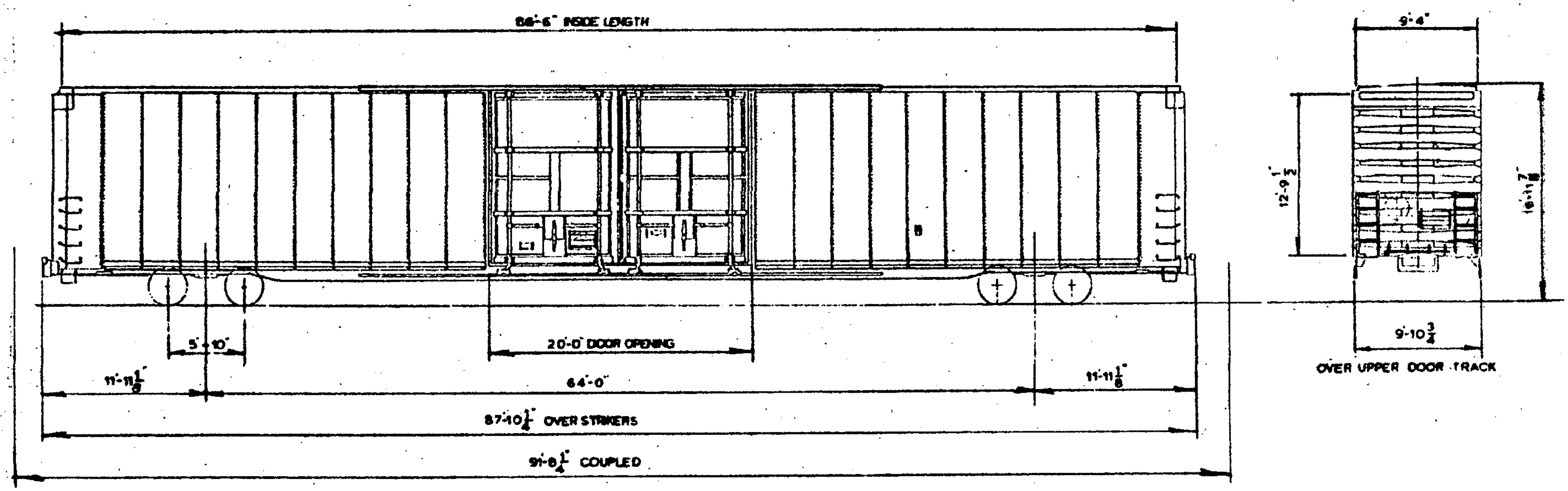


Pullman Standard 100-Ton 60'9" Box Car.

Source 1



Conrail Hi-Cube Car.
Built for auto parts service, it is equipped with movable bulkheads and 15 in. end-of-car cushioning. Rated capacity is 148,000 lbs. or 10,000 cu. ft. Outside dimensions are 92 ft. 6 in. long, 9 ft. 9 in. wide and 17 ft. high. Inside dimensions are 86 ft. 6 in. long, 9 ft. 2 in. wide and 12 ft. 9 in. high. The door opening is 20 ft. wide by 12 ft. 9 in. high. Built by Greenville Steel Car Co., 1978.



GREENVILLE STEEL CAR COMPANY

Source 1

GONDOLA CAR

<u>General Size</u>

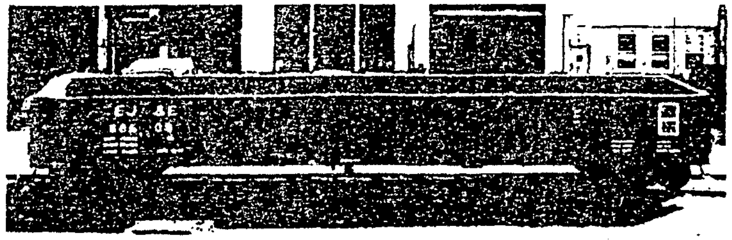
Fifty and 60 foot length cars with 70 and 100 ton capacities.

<u>Type</u>

Fixed ends and solid floor. Side heights vary relative to product needs. Increased use of dividers and tie-downs.

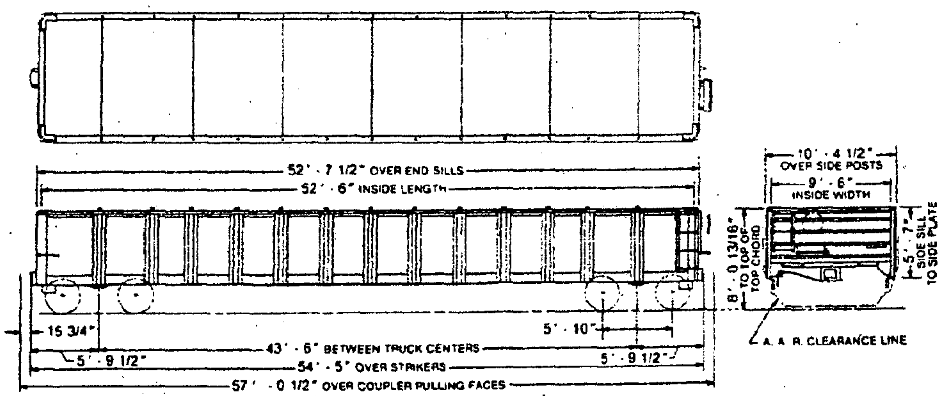
<u>Typical Load</u>

Forest products, steel products and machinery in open gondola. With special covers carry products requiring weather protection including steel sheet in coils or bundles.

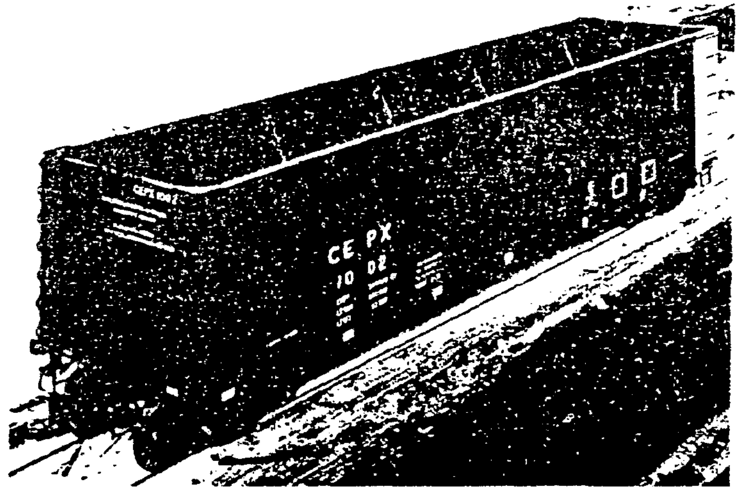


Elgin, Joliet & Eastern General Service Gondola
Inside length 52'6". Capacity 197,000 lbs., cubic capacity 2,244 cu. ft. See general arrangement diagram for dimensions. Built by Pullman Standard, 1975.

PULLMAN STANDARD

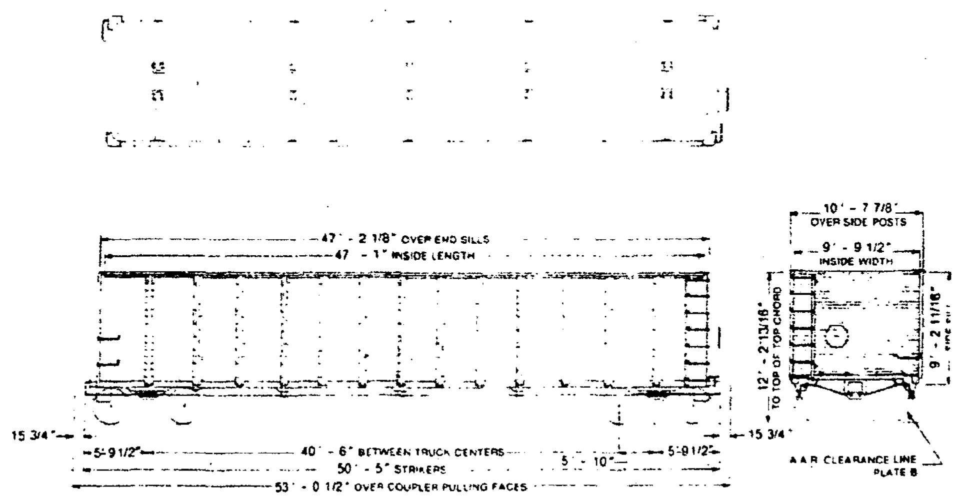


Pullman Standard 2244 cu. ft. General Service Gondola.



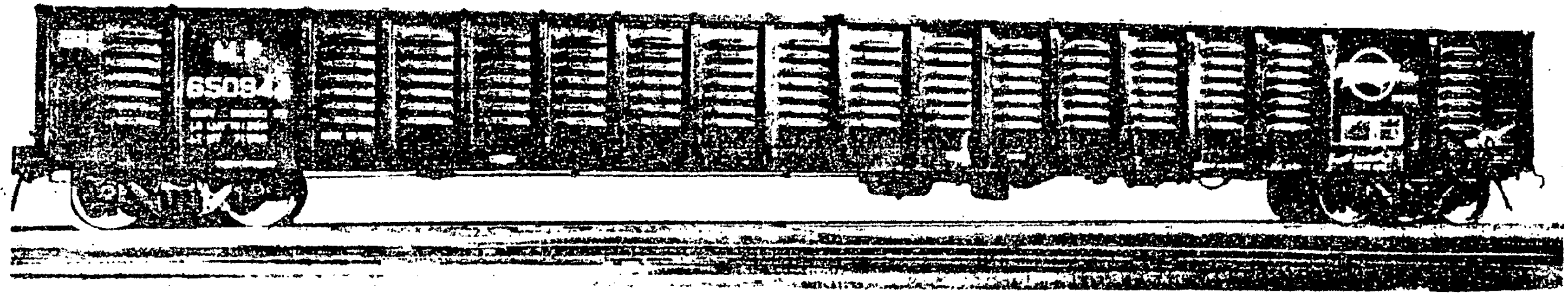
Cajun Electric Power Company High Side Gondola.
Capacity 200,000 lbs., cubic capacity 4000 cu. ft. Designed for rotary dump coal unit train service. See general arrangement for dimensions. Built by Pullman Standard, 1979.

PULLMAN STANDARD

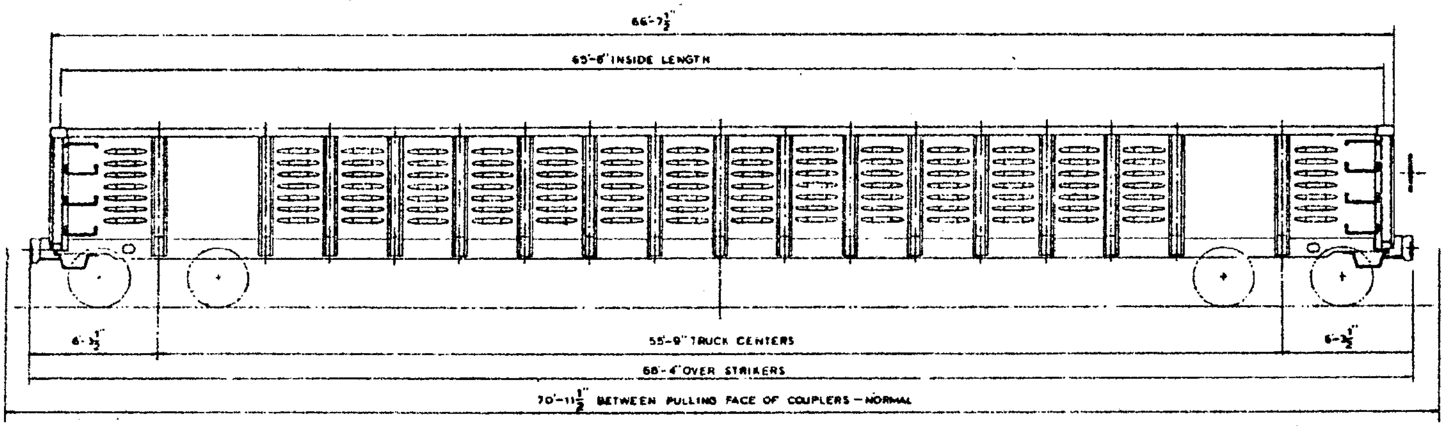


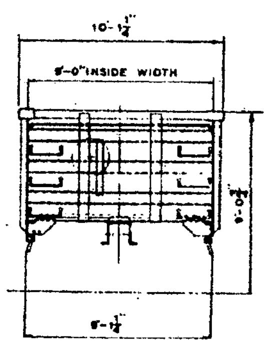
Pullman Standard 4000 cu. ft. High Side Gondola.

Source 1



Missouri Pacific Railroad 100-Ton Gondola.
Inside length 65 ft. 6 in., inside width 9 ft. 0 in., inside height 5 ft. 6 in., length over pulling face coupler 70 ft. 11 in., extreme width 9 ft. 11 in., extreme height 9 ft. 1 in., rated capacity 190,000 lbs. or 3242 cu. ft. Built by Greenville Steel Car Co., 1979.





GREENVILLE STEEL CAR COMPANY

Source 1

HOPPER CARS--OPEN TOP

<u>General Size</u>

Seventy and 100 tons. Most new cars with 100 ton capacity.

<u>Type</u>

Self clearing with open top and fixed sides and ends. "HT" with three or more divided hoppers with doors hinged crosswise of car and dumping between the rails. "HK" cars with two or more divided hoppers and doors hinged lengthwise of car can dump outside and/or inside of rails.

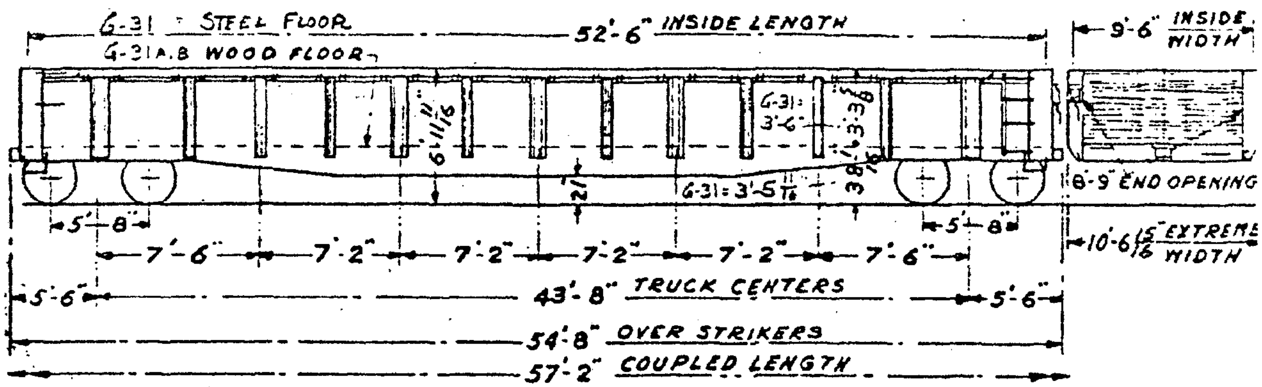
<u>Typical Load</u>

Coal, ores, stone and ballast. High density materials benefitting from self-clearing.

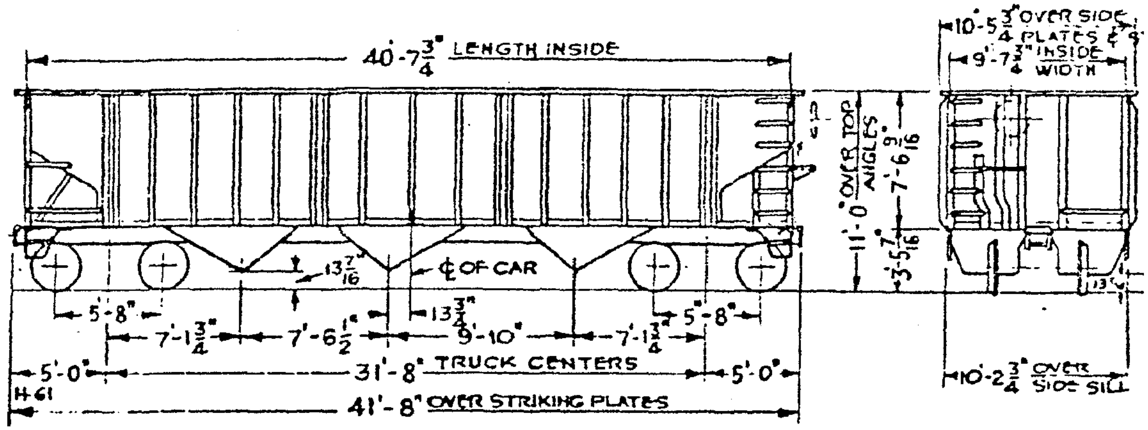
CAPACITY 140,000 LBS.
WEIGHT 55,100 LBS. (G31 A,B)
54,600 LBS. (G31)

K,L
G-31 A,B CAPACITY IN CU.FT.
" BOX 1646 (G-31 = 1745)
" HEAP 415 (" 405)
" TOTAL 2061 (" 2150)

GONDOLA CAR-DROP ENDS-CLASS G31,B,A BLT. 1950,'52

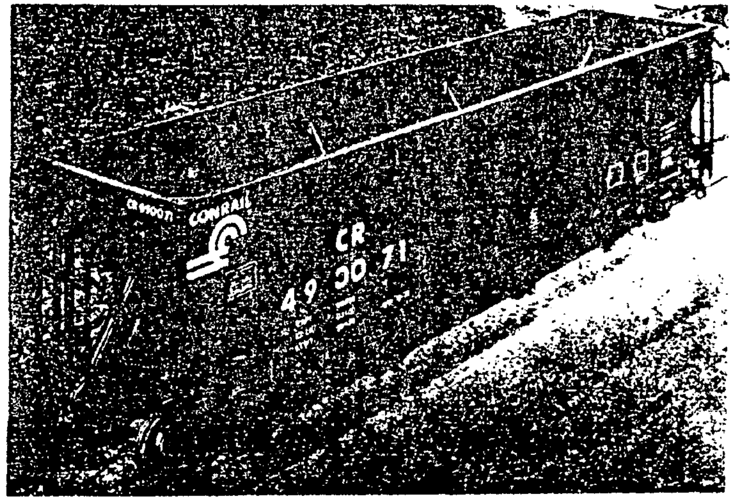


Source 3



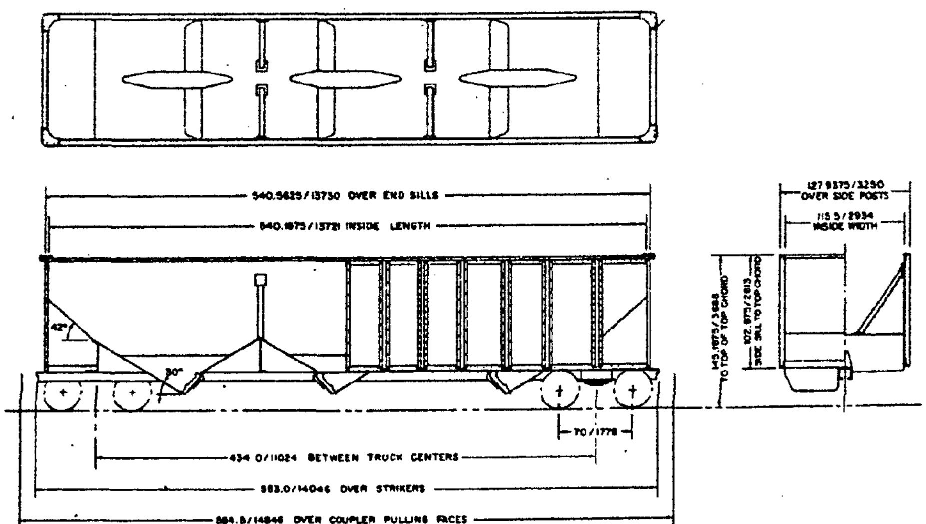
Series	No. Cars	Desig.	Capy C.F.	Load Limit	Light Weight	Builder	New	Lot No.
NYC 900000-901499)	1914	HT	2700	169300	50700	ACF	1956-57	866-H
NYC 901500-901999)		"	"	"	"	Gen.Amer.(8097)	1957	867-H
NYC 905000-905999)	1897	"		170000	50000	Greenv. (678)	1956-57	868-H
NYC 906000-906999)		"	"	"	"	Plm.Std. (8333)	1957	869-H
B&A 910000-910649	103	"	"					
NYC 919000-919999)		"	"	169300	50700	DSI (916,922)	1957	865-H

Source 3



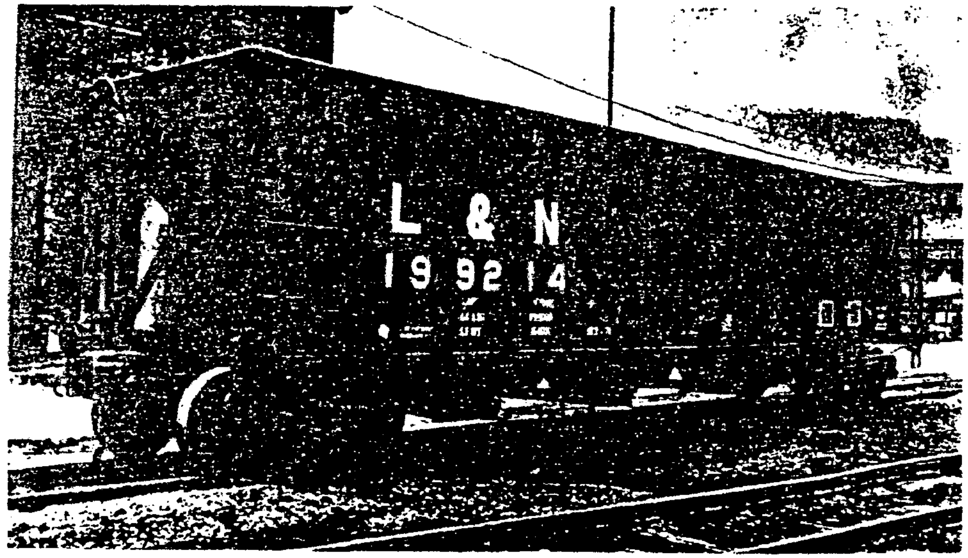
Conrail Triple Hopper Car.
Capacity 200,000 lbs., cubic capacity 3420 cu. ft. Smaller cubic foot capacity to suit heavier Eastern coal requirements. For rotary or bottom dump coal service. See general arrangement diagram for dimensions. Built by Pullman Standard, 1978.

PULLMAN STANDARD



Pullman Standard 3420 Open-Top Hopper.

Source 1



Open Top Hopper

GENERAL SPECIFICATION

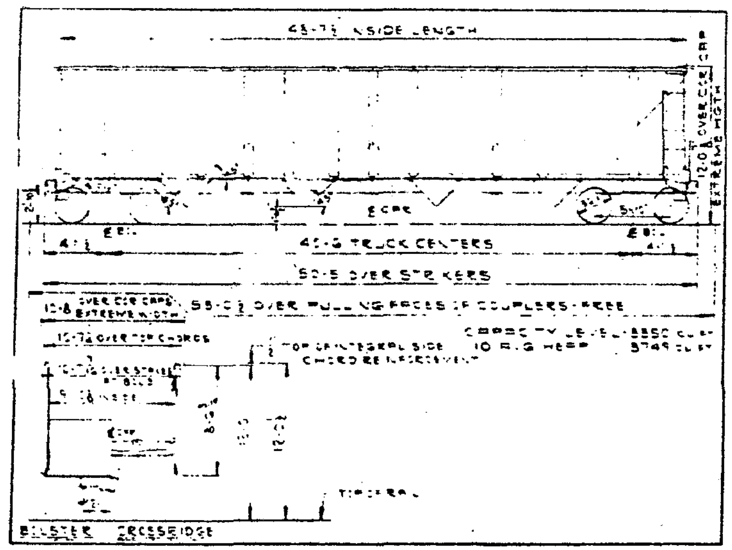
FOR L & N

100 TON QUADRUPLE HOPPER CARS

BETHLEHEM STEEL CORPORATION

GENERAL DIMENSIONS:

Length Inside	48' - 7-1/2"
Over Strikers	50' - 5"
Over Pulling Faces of Free Couplers	53' - 0-1/2"
Truck Centers	40' - 6"
Width Inside	9' - 10-1/8"
Over Top Chords	10' - 7-1/4"
Over Corner Caps (Extreme Width)	10' - 8"
Height Rail to Top of Side Top Chord	12' - 0"
Rail to Top of Corner Cap (Extreme Height)	12' - 0-7/8"
Rail to Centerline Coupler	2' - 10-1/2"
Center Plate	2' - 1-1/2"
Side Bearing Centers	4' - 2"
Cubic Capacity Level	3350 Cu. Ft.
10" Average Head	3749 Cu. Ft.



Source 1

General Size

Ranging from 40 foot -- 100 ton to 55 foot -- 100 ton relative to density of load.

Type

Permanently enclosed, with or without insulation, side or top weather-tight covers or doors for loading bulk commodities. Pressure flow top loading, bottom unloading "LO" illustrated here.

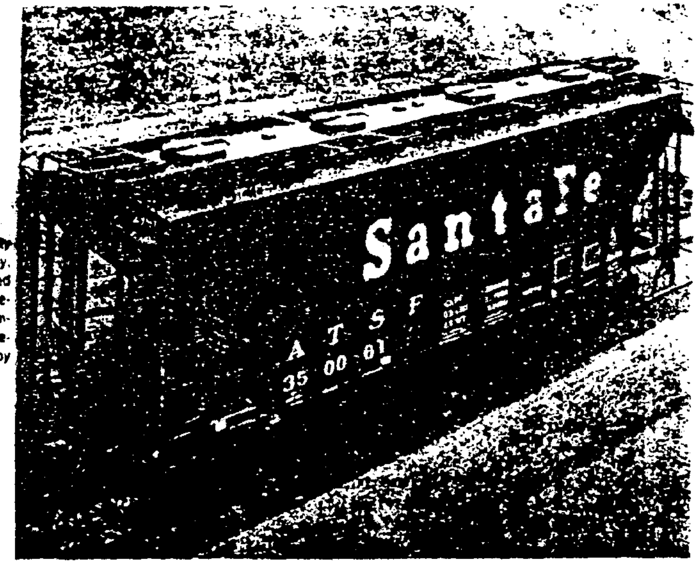
Typical Load

Bulk commodities requiring weather protection and possibly a controlled environment. Primarily chemical and petro-chemical related uses in New Haven environment. Loads include cement (high density) and styrene and polyethylene plastic pellets (low density). Cement might be carried in up to a 100-ton -- 3,500 cubic foot flexi-flow car (off-loaded relative to density) while plastic pellets are carried in 4,700 cubic feet and possibly 5,700 cubic foot cars.[1]

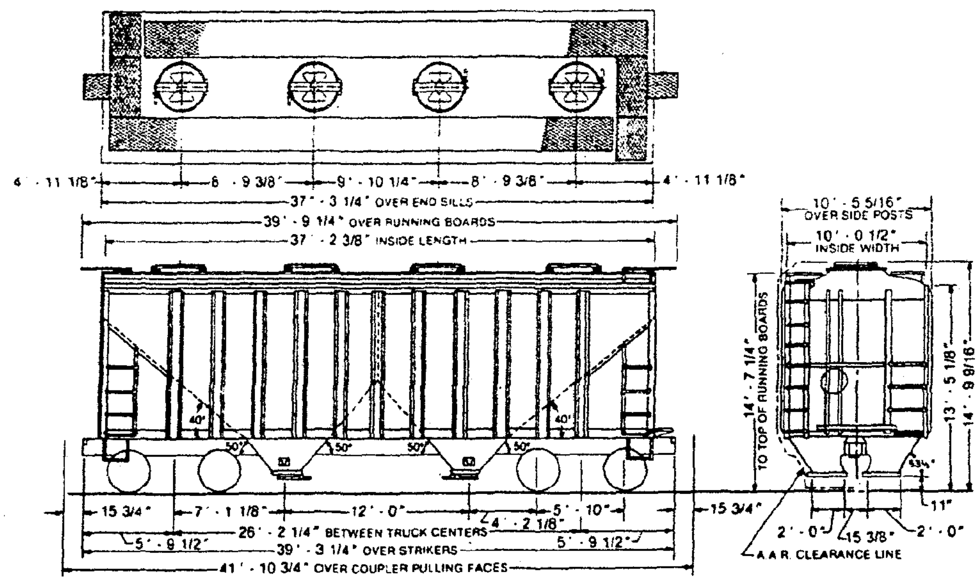
---

(1) flexi-flow permits pressurized (forced air mixing with materials) loading and discharge -- an efficient means of materials handling.

Santa Fe Covered Hopper Car. Capacity [illegible] lbs., cubic capacity 3000 cu. ft. Twin hoppers and gravity side discharge arrangement. Equipped with 30" round hatches. Built for cement service or other heavy bulk commodity lading. See general arrangement diagram for dimensions. Built by Pullman Standard, 1978

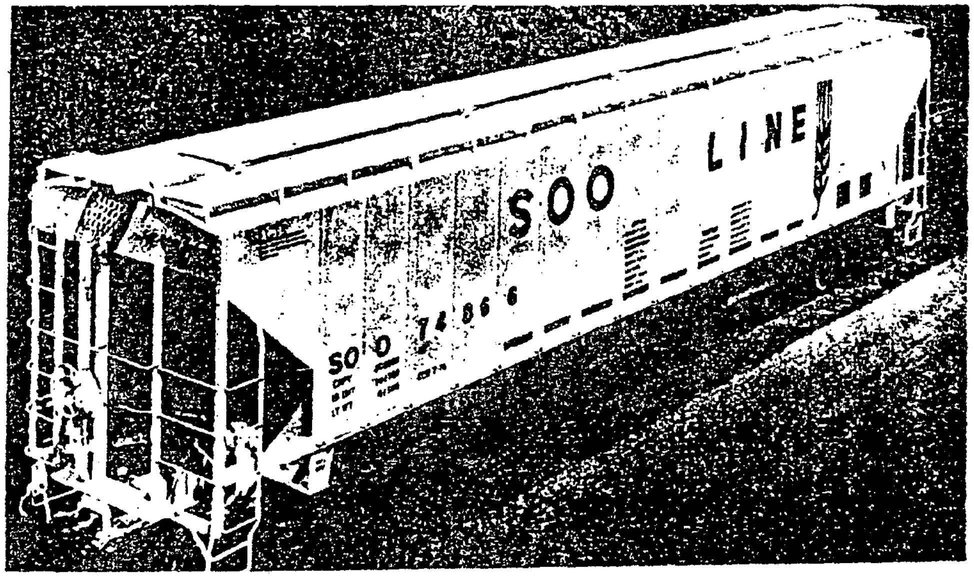


PULLMAN STANDARD



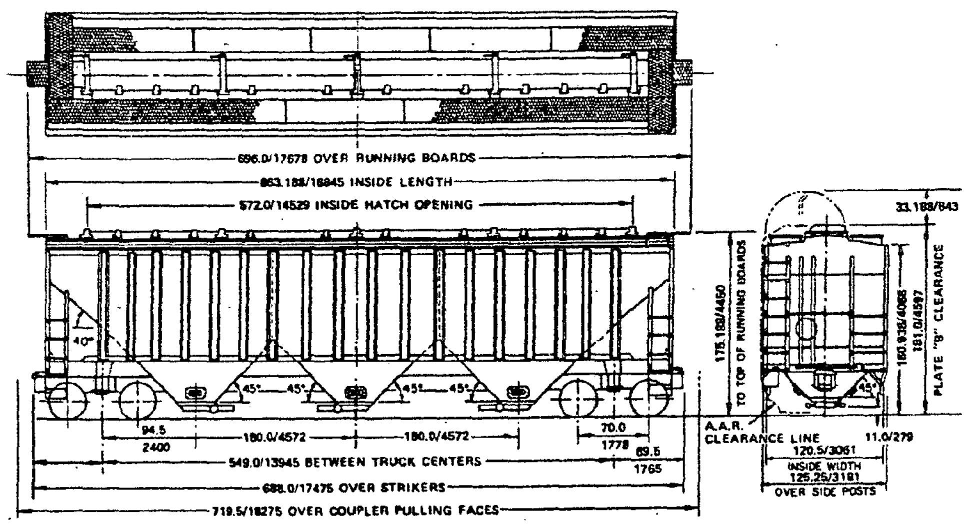
Pullman Standard 3000 cu. ft. Covered Hopper Car.

Source 1



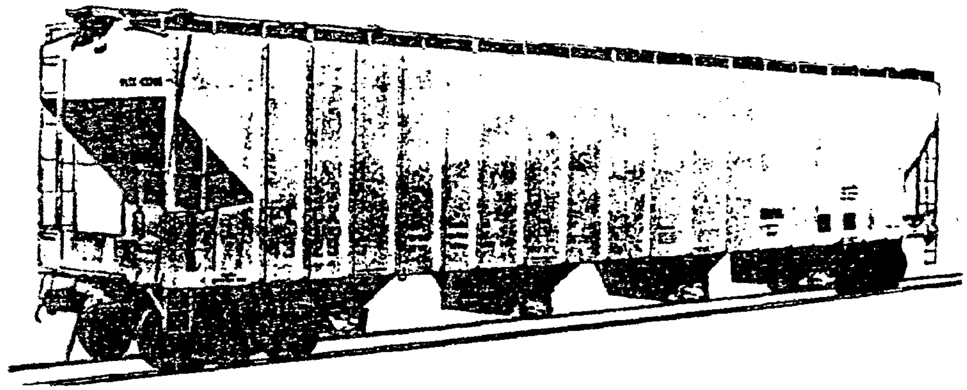
Soo Line Covered Hopper Car.
Capacity 200,000 lbs., cubic capacity 4750 cu. ft. With 24-inch wide trough hatch, triple hoppers and gravity discharge. Built for grain and other medium-density ladings. *See general arrangement diagram for dimensions. Built by Pullman Standard, 1978.*

PULLMAN STANDARD



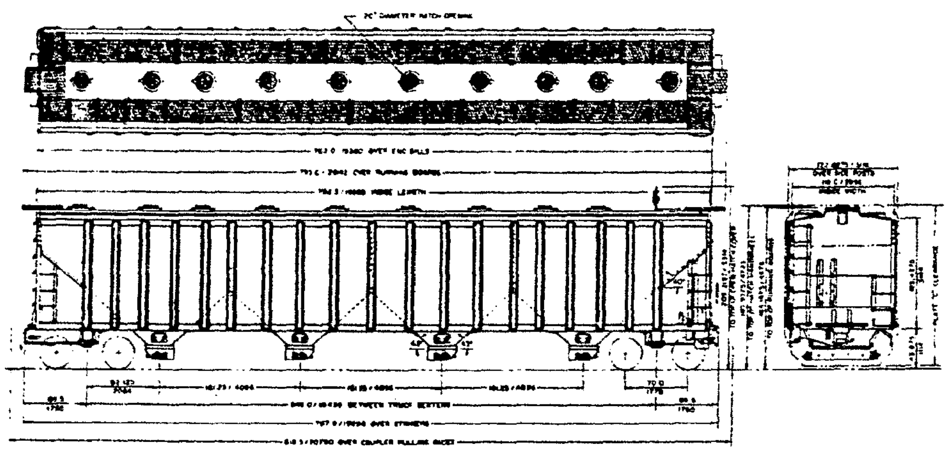
Pullman Standard 4750 cu. ft. Covered Hopper Car.

Source 1



Pullman Leasing Company Covered Hopper Car.
Capacity 192,000 lbs., cubic capacity 5820 cu. ft. Four hoppers and pneumatic outlet gates. Equipped with 20" round hatches. Built for light density products such as plastic pellets. See general arrangement diagram for dimensions. Built by Pullman Standard, 1978.

PULLMAN STANDARD



Pullman Standard 5820 cu. ft. Covered Hopper Car.

Source 1

FLAT CARS

General Size

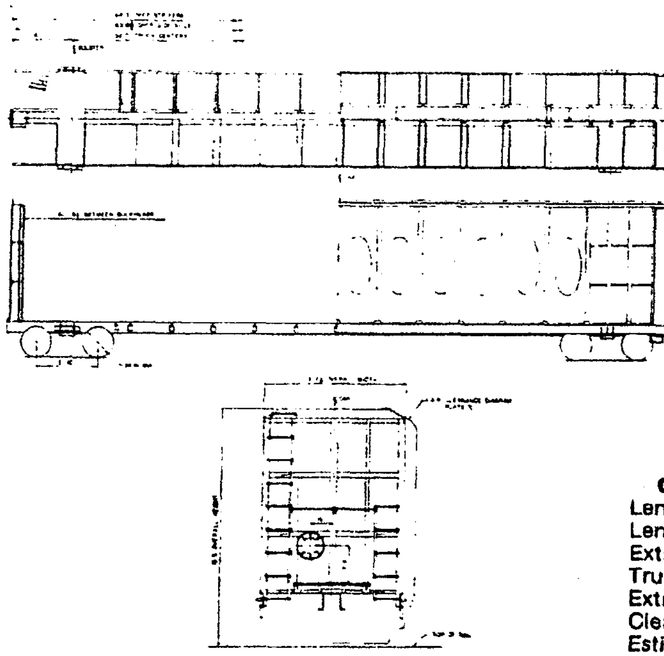
Generally 50 foot lengths and 100 ton capacities in this area.

Type

FM or ordinary flat car for general service and FC equipped to carry trucks, trailers or removable trailer bodies. Firm securement possible with bulkhead cars.

Typical Commodities

Pulpwood, plywood and plasterboard; packaged, finished lumber; steel products when covered; trailers (TOFC) and containers (COFC); and specialized products with cradles (auto parts) and tie-downs (machinery).



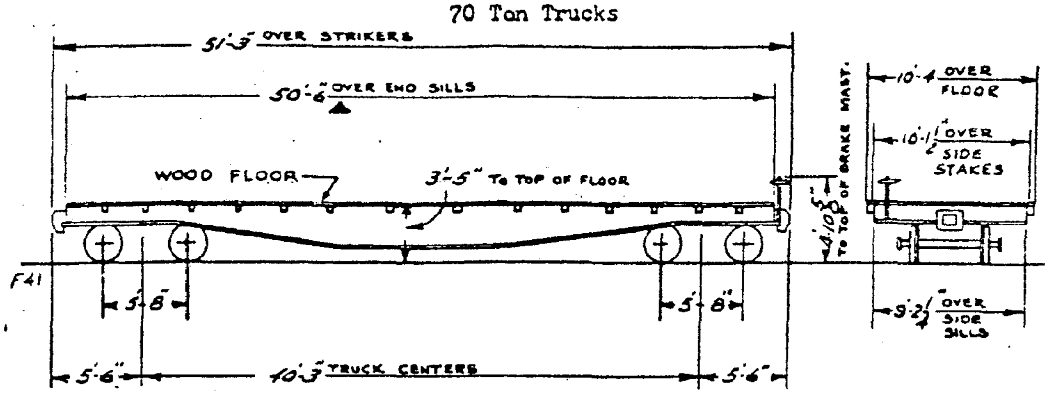
THRALL CAR MANUFACTURING COMPANY

General Dimensions —
CENTER BEAM BULKHEAD FLAT CAR

Length over strikers	64'2"
Length between bulkheads	60'8½"
Extreme width	9'2½"
Truck Centers	52'
Extreme height	15'5"
Clearance	Plate "C"
Estimated light weight	63,000 Lbs.

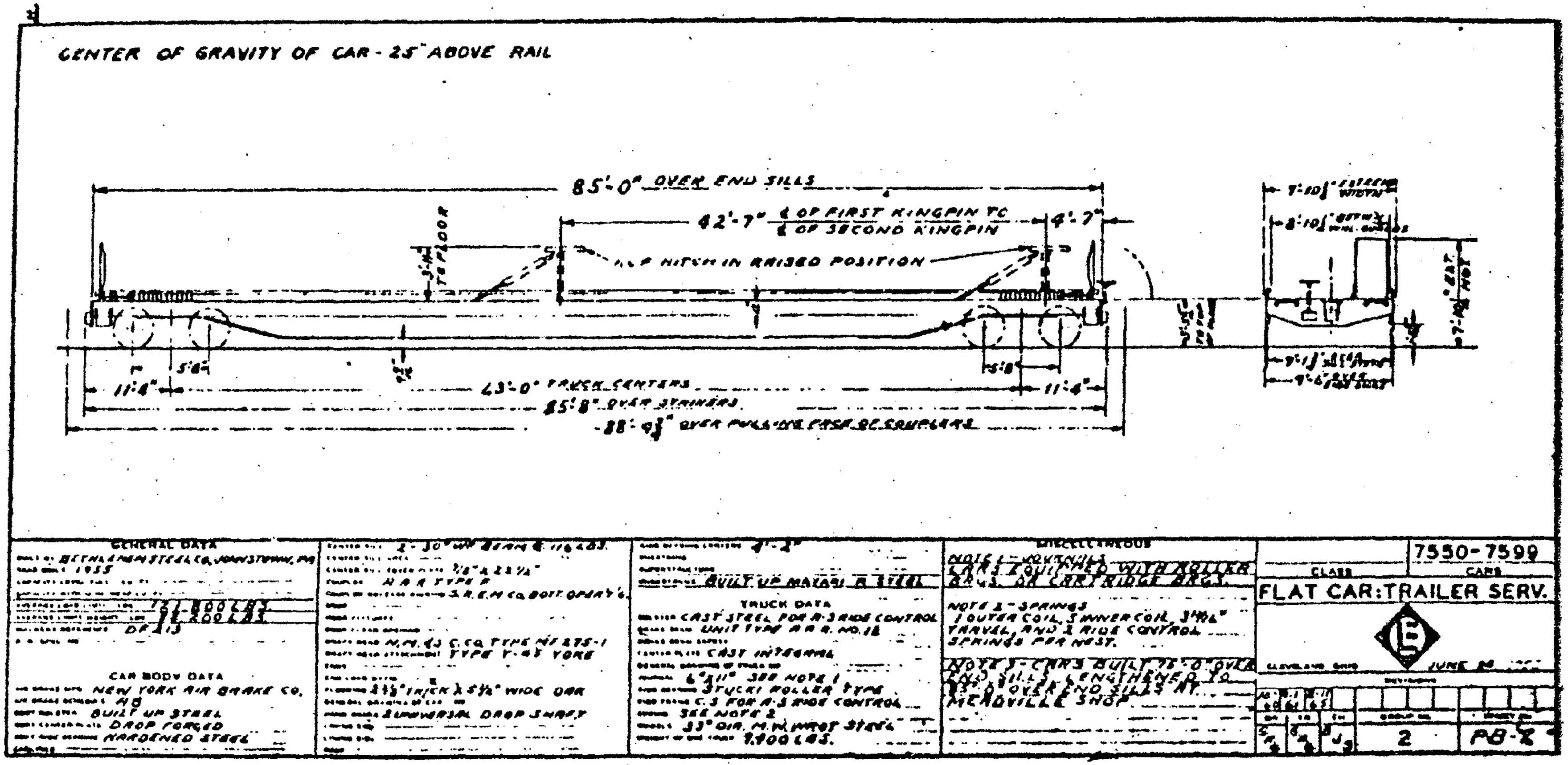
Source 1

50 FOOT FLAT
70 Ton Trucks



	Series	Cars	Des.	Ld.Lmt.	Lt.Wt.	Shop.Prog.	Builder & Order	New	Lot
NYC	500300-500799	370	FM	162900	57100	70 line 33	Gen.Amer.	1953	23-F

Source 3


CENTER OF GRAVITY OF CAR - 25" ABOVE RAIL
85'-0" OVER END SILLS
42'-7" ℄ OF FIRST KINGPIN TO ℄ OF SECOND KINGPIN
4'-7"
HITCH IN RAISED POSITION
T/FLOOR
5'-8"
11'-4"
43'-0" TRUCK CENTERS
85'-8" OVER STRIKERS
88'-9⅞" OVER PULLING FACE OF COUPLERS
GENERAL DATA
BETHLEHEM STEEL CO, JOHNSTOWN, PA
1955
121,800 LBS
DF 213
CAR BODY DATA
NEW YORK AIR BRAKE CO.
AB
BUILT UP STEEL
DROP FORGED
HARDENED STEEL
2-30" WF BEAM @ 116 LBS.
N.Y.B. TYPE F
S.R.E.M CO. BOTT. OPER'G.
N.M. 43 C.CO TYPE NF 275-1
TYPE Y-45 YOKE
UNIVERSAL DROP SHAFT
BUILT UP MAYARI R STEEL
TRUCK DATA
CAST STEEL FOR A-3 RIDE CONTROL
UNIT TYPE A.A.R. NO. 18
CAST INTEGRAL
6"x11" SEE NOTE 1
STUCKI ROLLER TYPE
C.S FOR A-3 RIDE CONTROL
SEE NOTE 2
33" DIA. M.W. WROT STEEL
MISCELLANEOUS
CARS EQUIPPED WITH ROLLER BRGS. OR CARTRIDGE BRGS.
NOTE 2 - SPRINGS
1 OUTER COIL, 5 INNER COIL, 3 11/16" TRAVEL, AND 2 RIDE CONTROL SPRINGS PER NEST.
NOTE 3 - CARS BUILT 75'-0" OVER END SILLS, LENGTHENED TO 85'-0" OVER END SILLS AT MEADVILLE SHOP
7550-7599
CLASS
CARS
FLAT CAR: TRAILER SERV.
2
PB-8

Source 3

General Size

Ranging from 16,000 to 34,500 gallon capacity to accommodate a wide range of densities within the 263,000 pound (loaded) weight.

Type

Pressurized and non-pressurized relative to commodity needs.

Typical Load

Crude oil and petroleum products; liquified gases (carbon dioxide, oxygen and hydrogen), polymers; anhydrous ammonia; chlorine, alcohol, vegetable and fish oils and acids.

16,000-GALLON CAUSTIC SODA CAR **S4P7**

SPECIFICATIONS

BASIC CAR DESIGN	35-100-16
DOT CLASS	111A60W-1

CAPACITY & WEIGHT

Nominal Capacity in Gallons	16,000
Shell Capacity in Gallons (nominal + 2% outage)	16,327
Allowable Weight Per Gallon, lbs.	12.5
Lightweight, lbs	62,900
Capacity, lbs.	200,100
Maximum Weight on Rail, lbs.	263,000

DIMENSIONS

Length Over Strikers	43' 7¼"
Length Over Truck Centers	30' 8½"
Maximum Width	10' 8"
Maximum Height	14' 9⅜"
Radius of Curvature Car Can Negotiate	202 ft.

TRUCKS, BRAKES & PLATFORM

Truck Design and Capacity	Barber 100 Ton
Journal Bearings	Roller
Wheel Size	36"
Air Brake Design	Conventional
Hand Brake Design	Vertical Hand Wheel
Operating Platform	2 Board 2 Way Entry

TANK

Design	Funnel-Flow®
Tank Plate Specification	A-285 GR-C
Plate Thickness of Shell	7/16"
Plate Thickness of Heads	15/32"
Outside Diameter of Tank Shell	106"
Tank Length Over Head Seams at Bottom	33' 6"
Tank Tested To	60 P.S.I.

HEATER PIPES

Design	Exterior Header Heater™
Inlets and Outlets	One 2" inlet; One 2" outlet
Number of Runs	8-6" Half Oval

INSULATION

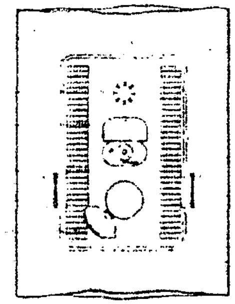
Thickness and Type	4" Fiberglass
Jacket	⅛" Steel

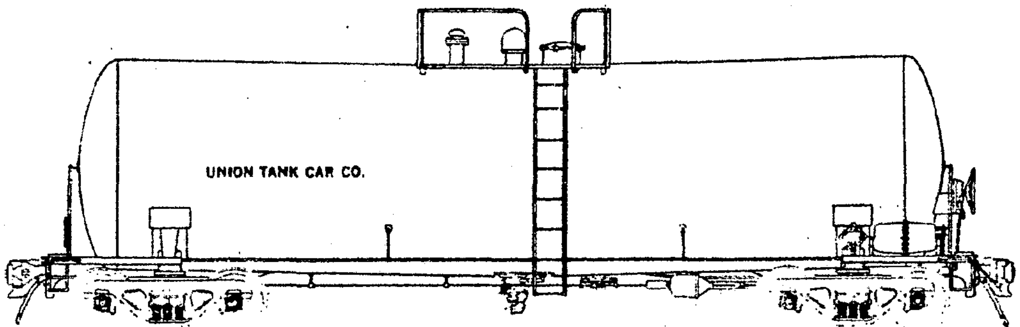
TOP FITTINGS

Manway	18"
Top Unloading Valve	2" Ball, Screwed, Steel Body & Ball
Siphon Pipe	2" Steel
Air Connection	1" Nipple, Capped
Gauging Device	Visual Bar, Stainless Steel
Safety Vent	45 P.S.I.
Vacuum Relief Valve	Stainless Steel

BOTTOM FITTINGS

Bottom Unloading Valve	4" Ball, Steel Body & Ball Steam Jacketed
Valve Connection	4" Cap With 2" Ball Valve





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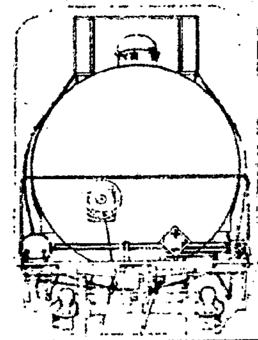


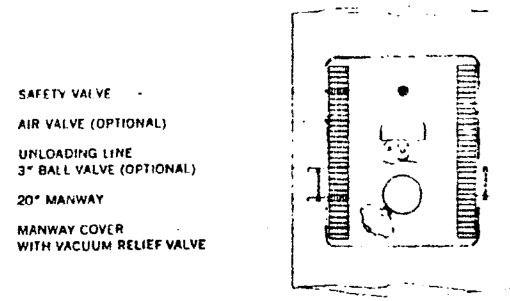
Source 2

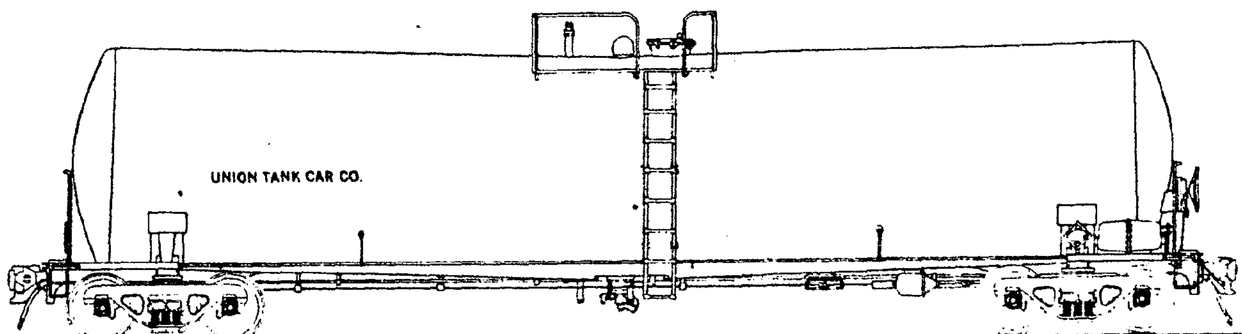
GENERAL PURPOSE
INSULATED HEATER-PIPED
23,000-GALLON CAR

S4P5

SPECIFICATIONS

BASIC CAR DESIGN	30-100-23
DOT CLASS	111A100W-3
CAPACITY & WEIGHT	
Nominal Capacity in Gallons	23,000
Shell Capacity in Gallons (nominal + 2% outage)	23,469
Allowable Weight Per Gallon, lbs	8.2
Lightweight, lbs.	74,300
Capacity, lbs.	188,700
Maximum Weight on Rail, lbs.	263,000
DIMENSIONS	
Length Over Strikers	52' 9½"
Length Over Truck Centers	41' 10½"
Maximum Width	10' 8"
Maximum Height	14' 8½"
Radius of Curvature Car Can Negotiate	202 ft.
TRUCKS, BRAKES & PLATFORM	
Truck Design and Capacity	Barber 100 Ton
Journal Bearings	Roller
Wheel Size	36"
Air Brake Design	Conventional
Hand Brake Design	Vertical Hand Wheel
Operating Platform	2 Board 2 Way Entry
TANK	
Design	Funnel-Flow®
Tank Plate Specification	A-515 GR 70
Plate Thickness of Shell	7/16"
Plate Thickness of Heads	15/32"
Outside Diameter of Tank Shell	111"
Tank Length Over Head Seams at Bottom	44' 7½"
Tank Tested To	100 P.S.I.
HEATER PIPES	
Design	Exterior Header Heater
Inlets and Outlets	One 2" inlet, One 2" outlet
Number of Runs	16-6" Half Oval
INSULATION	
Thickness and Type	4" Fiberglass
Jacket	1/8" Steel
TOP FITTINGS	
Manway	20"
Top Unloading Valve (Optional)	3" Ball, Flanged Steel Body & Ball
Siphon Pipe (Optional)	3" Steel
Air Connection (Optional with valve)	Nipple, Capped
Gauging Device	Visual Bar—Steel
Safety Valve	75 P.S.I.
Vacuum Relief Valve	Stainless Steel
BOTTOM FITTINGS	
Bottom Unloading Valve	4" Ball, Steel Body & Ball
Valve Connection	4" Adapter with 2" Plug





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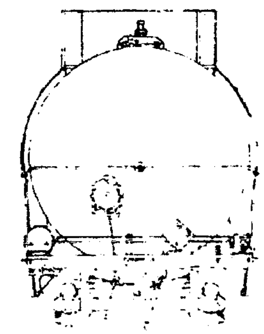


Source 2

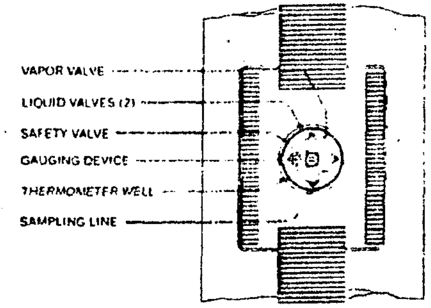
33,800-GALLON
ANHYDROUS AMMONIA
& LP GAS CAR

S4P11

SPECIFICATIONS

BASIC CAR DESIGN	67-100-34J
DOT CLASS	112J340W
CAPACITY & WEIGHT	
Nominal Capacity in Gallons	33 800
Allowable Weight Per Gallon, lbs	Per Tariff
Lightweight, lbs	102 200
Capacity, lbs	160 800
Maximum Weight on Rail, lbs	263 000
DIMENSIONS	
Length Over Strikers	65' 5"
Length Over Truck Centers	54' 6"
Maximum Width	10' 8"
Maximum Height	15' 6"
Radius of Curvature Car Can Negotiate	255 ft
TRUCKS, BRAKES & PLATFORM	
Truck Design and Capacity	Barber 100 Ton
Journal Bearings	Roller
Wheel Size	36"
Air Brake Design	Conventional
Hand Brake Design	Vertical Hand Wheel
Operating Platform	2 Board 4 Way Entry

TANK	
Design	Straight Shell
Tank Plate Specification	AAR M128 GR B
Plate Thickness of Shell	[illegible]"
Plate Thickness of Heads	[illegible]"
Outside Diameter of Tank Shell	119 3"
Tank Length Over Head Seams	56' 1"
Tank Tested To	340 P.S.I.
INSULATION	
Thickness and Type	1" Mineral Wool
Jacket	[illegible]" Steel
Jacket Heads (Top Half)	[illegible]" Steel
Jacket Heads (Bottom Half)	[illegible]" Steel Head Shields
FITTINGS	
Manway	18" Pressure type
Liquid Lines (two)	3" Steel Pipes
	3" Excess Flow Valves
	2" Ball Type Angle Valves, Steel Bodies & Balls
Vapor Line	Excess Flow Valve Beneath 2" Ball Type
	Angle Valve, Steel Body & Ball
Thermometer Well	Steel
Sampling Line	[illegible]" Steel & SS
Safety Valve	280.5 P.S.I.
Gauging Device	MGM #62-B Slip Tube Type



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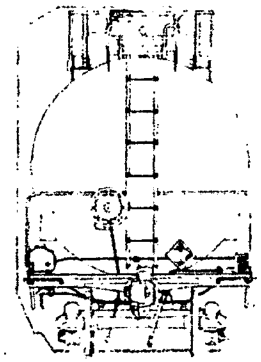
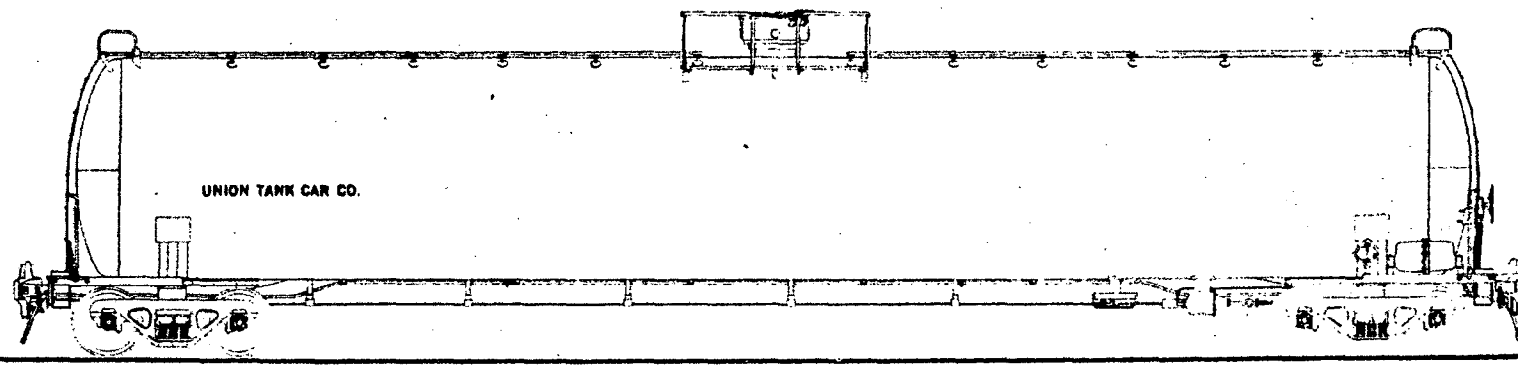




Source 2

APPENDIX B
TRAIN TONNAGE

Effects of grade and curvature on tonnage capacities are estimated per Railroad Engineering and a basic resistance equation of[1]

$$R_u = (1.3 + 29/w + bV + CAV^2/wn)\ .85, \text{ where}$$

R_u = unit resistance in pounds per ton

w = weight per axle in tons or weight on rail in tons/the number of axles

b = experimental coefficient based on flange friction, shock, sway and concussion (0.03 for locomotive and 0.045 for freight cars).

A = cross sectional area in square feet of car or locomotive (120 for locomotive and 85 for freight cars).

C = drag coefficient of the car or locomotive (0.0024 for locomotive and 0.0005 for freight cars).

V = velocity or speed. 7.5 mph assumed on Forbes Avenue.

Adhesion rates of between 20 and 25 percent at 7.5 to 10 mph are used correlate with contemporary locomotive capabilities and track conditions. Manufacturers' suggested 25 percent adhesion rates assume ideal track conditions. A combination of curvature and grade establish "worst case" or controlling conditions.

(1) William W. Hay, Railroad Engineering: Second Edition (New York: John Wiley, 1982), Chapter 7 and Appendix A.

Ruling Conditions

Motive Power: One 246,000 SW 1500 locomotive, 4 axles, 123 tons, 61,500 pounds tractive effort at 25 percent adhesion, 49,200 pounds tractive effort at 20 percent adhesion.

Equipment: 100 ton nominal capacity, 263,000 pound weight on four axles or 32.9 tons per axle. Alternately 50 foot (coupled) open hoppers and 55 foot (coupled) tank cars.

Grade and Curves (with new 12^{o} - 30' curves):

(1) WB Approach (east shore)
   a. $\pm$ 275', 12^{o} 30' curve with 0.3% grade.

   b. $\pm$ 825' tangent with 1.5% grade.

(2) EB approach (west shore)

   a. $\pm$ 275' 12^{o} 30' curve with 1.4% grade.

   b. $\pm$ 230' tangent with 2.3% grade.

   c. $\pm$ 180' tangent with 0% grade.

Locomotive Resistance

$$R_L = (1.3 + 29/w + (bV + CAV^2/wn))\ .85 \times 246$$

$$= 1.3 + 29/30.75 + (0.3 \times 7.5) + \frac{(.0024 \times 120 \times 56.25)}{123} \times .85 \times 123$$

$$= 271 \text{ lb.}$$

R_L on WB tangent

R_L = 271 + (123 + 20 x 1.5) = 3,961 lb.

R_L on EB tangent

R_L = 271 + (123 x 20 x 2.3) = 5,929 lb.

Drawbar Pull

A. With 25% adhesion

DBP WB = 61,500 - 3,961 = 57,539 lb.
DBP EB = 61,500 - 5,921 = 55,571 lb.

B With 20% adhesion

DBP WB = 49,200 - 3,961 = 45,239 lb.
DBP EB = 49,200 - 5,929 = 43,271 lb.

Car Resistance (Unit or Each Car)

$$R_c = (1.3 + 29/32.9 + (.045 \times 7.5) + \left(\frac{.0005 \times 90 \times 56.25}{32.9}\right) \quad .85$$

$$= 2.2 \text{ lbs}$$

Unit on WB Curve Approach:

$$R_c = 2.2 + (20 \times .3) + (20 \times 12.5 \times .05) = 20.7 \text{ lbs.}$$

Unit on WB Tangent Approach:

$$R_c = 2.2 + (20 \times 1.5) = 32.2 \text{ lbs.}$$

Unit on EB Curve Approach:

$$R_c = 2.2 (20 \times 1.4) + (20 \times 12.5 \times 0.5) = 42.7 \text{ lbs.}$$

Unit on EB Tangent Approach:

$$R_c = 2.2 + (20 \times 2.3) + 48.2 \text{ lbs.}$$

Train Tonnage - Tankers (55' coupled length)

EB Approach:

5 cars (275') on curve 4 cars (235') on tangent with 2.3% grade and others (up to 385') on level tangent

R_c = (5 x 42.7 x 131.5) + (4 x 48.2 x 131.5) + (7 x 2.2 x 131.5)

= 55,453 lbs = 16 cars with 55,571 DBP (25%)

or 40,752 lbs = 7 cars with 43,271 DBP (20%)

WB Approach:

5 cars (275') on curve, up to 11 cars (605') on tangent with 1.5% grade

R_c = (5 x 32.2 x 131.5) + (13 x 20.7 x 131.5) = 56,558 lbs.

or 18 cars with 57,539 DBP (25%) or 42,948 lbs = 13 cars with 45,239 DBP (20%)

Train Tonnage -- Open Hoppers (50' coupled length)

EB Approach:

6 cars (275') on curve, 5 cars (250') on tangent with 2.3% grade and others (up to 385') on level tangent.

R_c = (6 x 42.7 x 131.5) + (3 x 48.2 x 131.5)

= 52,705 = 9 cars with 55,571 DBP (25%)

or 40,028 = 6 cars with 43,271 DBP (20%)

WB Approach:

6 cars (275') on curve, up to 12 cars (605') on tangent with 1.5% grade

R_c = (6 x 42.7 x 131.5) + (8 x 20.7 x 131.5)

= 55,466 lbs. = 14 cars with 57,539 DBP or

41,856 lbs = 9 cars with 42,948 DBP.

Appendix C

Seelye, Stevenson, Value and Knecht Materials

Appendix C contains:

- SSVK's February, 1984 memo summarizing Tomlinson Bridge structural problems; and

- SSVK's working notes which broadly suggest the inability of the existing Tomlinson Bridge to support 263,000 pound rail cars. "Unchecked" SSVK materials are offered correlate with the planning orientation of this effort. Worksheets pertain to:

sheet 1:	the general orientation of rail vehicles.
sheets 2 and 3:	span 2.
sheets 6 thru 8:	the cantilever between pier 1 and the adjacent hung span.
sheets 9 and 10:	span 1 between the abutment and pier 1.
sheets 10 and 11:	span 3.
sheets BG1 thru BG9:	the bascules.

Tomlinson Bridge Over Quinnipiac River

Description of Site

The Tomlinson Bridge Structure on Forbes Avenue spanning the Quinnipiac River in New Haven is on a tangent roadway alignment within the structure limits. It is a state road (Route 1) which accommodates rail traffic as well as vehicular traffic.

The bridge structures consists of three fixed spans at each approach to a double leaf bascule span placed at mid-channel. The approach spans consist of variable depth steel girders designed to accommodate a twenty four (24) foot hung span at the center span of each approach. The present deck system consists of a structural concrete deck slab supporting a concrete ballast in which the railroad ties and tracks are embedded. The deck surface has asphalt overlay replacing the original roadway surface of creosoted paving blocks. The four (4) interior girders are so oriented that each girder supports the wheel loads from one train on a two track rail system.

The double leaf bascule at mid-channel consist of four (4) variable depth girders supporting trussed and/or solid floor beams with an open steel grating floor system. The grating is supported by steel stringers and a transverse channel support system. The two (2) interior bascule girders support eighty (80) percent of the rail loading from a two track rail system.

A limited design check by Seelye, Stevenson, Value, and Knecht was made of the existing structure to see if the present structure could possibly support heavier car loadings. In researching the original design it appears certain liberties had been taken in setting the design parameters, such as:

1. The flexural tensile stress of 24,000 lbs. per square inch was used for design although the A.R.E.A.. Codes in the 1920's used a 16,000 lbs. per square inch allowable. Today higher unit stress can be used by A.R.E.A. Code based on the ultimate strength and minimum yield point strength of the high strength steel used. In those days the use of these higher design stresses without proper quality control in manufacture is questionable.

2. The impact factor diagram for 200,000 lb. cars in the 1922 Tomlinson Design Specifications provides impact percentages much less than the A.R.E.A. Code of the time; leading to a less conservative design for this railway structure.

   As stated above, an in-depth design analysis of the existing structure could not be done within the time frame and monies allotted for this check. A basic check of the major structural supports of both the approach structures and bascule span was made utilizing the dead load moments from the existing 1916 Contract drawings and moments from a proposed 252,500# Engine with 263,000# rail cars. The design paramenters used for checking the existing structure for the above train loading were:

1. The original tensile design stress of 24,000 lbs. per square inch was used as the maximum allowable stress (although we question its original use).

2. Impact factors from the current A.R.E.A. Code for diesel engines were used for the design check with new loadings.

3. Gross sections were used, not net sections, to check support capabilities of the main track girders. (This is only a quick check to see if the increased loadings are close to the maximum allowable design stress limits).

4. Fatigue considerations were not addressed in this limited stress check of main members.

Design Check Conclusions Using Heavier Rail Loadings

A. In fixed approach span #1, the track girders are over-stressed approximately 15% in the maximum positive moment area.

B. At Pier #1, the stress in the negative moment area (cantilever) of the track girders are over-stressed approximately 15%.

C. The hung (23'-10") track girders in the center span are over-stressed approximately 30%.

D. At Pier #2, the stress in the negative moment area (cantilever) of the track girders appear to be less than the allowable original design stress of 24,000 lbs. per square inch.

E. In the fixed approach span #3, the track girders are over-stressed approximately 15% in the maximum positive moment area.

F. The interior bascule girders supporting the double tracks will be over stressed approximately 15% in the maximum cantilever moment area.

Conclusions (Limited Investigation):

If the present structure has not deteriorated in the main support areas of the approach spans, where the structure elements are hidden by a gunite encasement, the existing framing system is still incapable of supporting an increased rail loading. If major deteriorat on is present, it may not be able to support the "original" design loadings. Of the over-stress which would be induced by heavier rail loadings, the "hung span" in span #2 approach spans would be over-stressed the most. In the bascule span, the over-stress in the main girders in the maximum cantilever moment area was checked and was over-stressed by approximately 15% for the proposed increase rail loads. In any in-depth analysis the live load anchorage, main trunnions and live load supports etc. must also be checked before more specific conclusions can be arrived at as to potential load capacities.

Field-Inspection

A one day site inspection was also made by "Seelye" personnel to check the condition of the bridge structure as well as the roadway approaches. The retaining walls at the west bridge approach appear to be in good condition, but the east bridge approach retaining walls have rotated where the south retaining wall abuts the end of the east abutment. Both the east and west abutments have experienced distress; the west abutment at the north end and the east abutment at both ends of the abutment face. The major distress in the east abutment is at the northeast corner where the abutment face is cracked and the north wingwall has rotated several inches, and is out of plumb. The rotation of the southeast wingwall of the east abutment has also rotated and has "pulled" the approach retaining wall with it. Also Pier #2 of the west approach spans, the pier stem between the four rail support girders has cracked. All other substructure units including the bascule piers "appear" to be in good condition. Failure of the existing bridge abutments and Pier #2 must be addressed if future rehabilitation and strengthening is proposed for any upgrading of the harbor rail network.

Recommendation

Since the movable portion of this bridge structure (bascule span) would be relatively expensive to strengthen if an increased rail loading was used with the double track system, it is possible that a single track placed between the two interior bascule girder could support an increased rail loading and be within the stress limits used for the original design. If this alternate is considered, the approach girders would still have to be strengthen even if the one track is placed at the roadway centerline;but strengthening the approach girders would be much simplier than any major modification to the bascule girders.

It is apparent that if rehabilitation of the existing structure is considered, the reuse of most substructure units and the bascule and approach span steel would be more economical than building a new structure at the present or new site if only one track is considered. The other plusses would be no additional land acquisition costs and possible use of the structure during rehabilitation by stage construction.

Additional Requirements If Rehabilitation Is Considered

Bascule Structure

A. Check Live Load Support Anchorage for major deterioration including a check to assess condition of the steel embedded below the pit floor.

B. All counterweight trunnion bearings should be checked and the existing bronze bushings replaced.

C. Counterweight truss hangers as well as the truss support system embedded in the counterweight concrete should be checked for deterioration.

D. Counterweight modification should be considered to allow for a greater bascule opening than presently exists to reduce the possibility of "bridge hits".

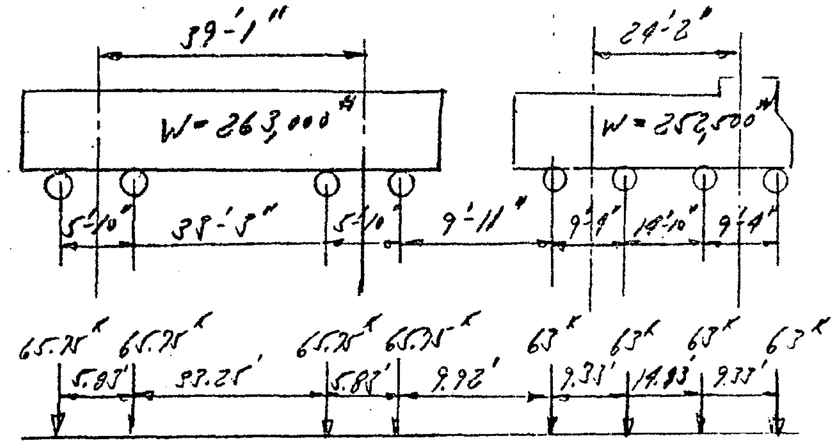
SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

JOB: Rail Study S.S.G.P.A. — NOTES BY: R.J.C. — DATE: 9/21/93 — PAGE NO. 1

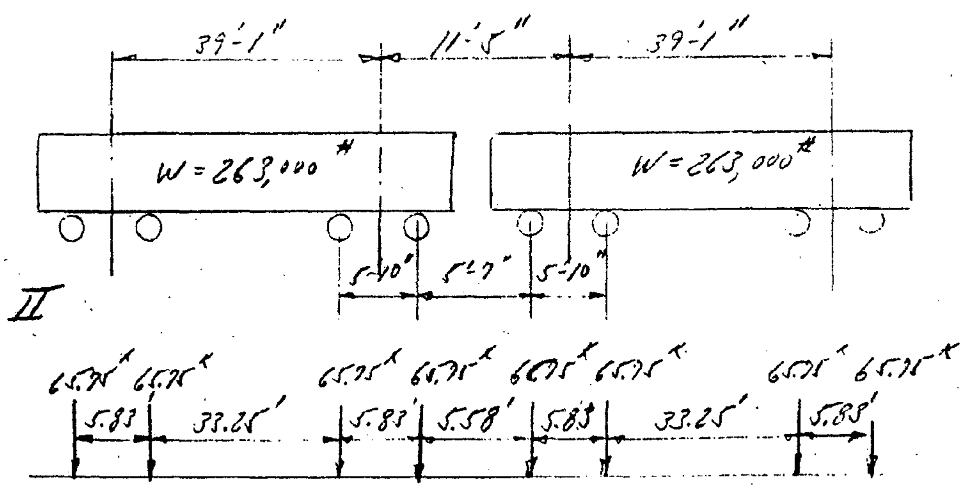
Bridge Capacity-Rail Study — CHECK BY: — DATE:

Bridge Loadings - Railroad

Case I

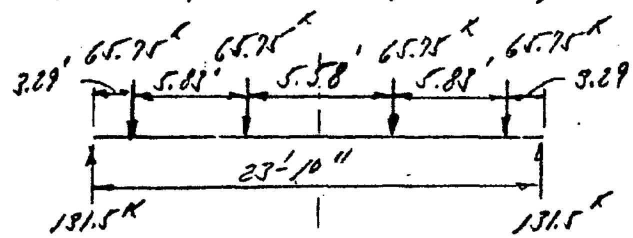


Case II



Simple Span in Span #2
Live Load Moment New Rail Loadings (Case II Loading)

Simple Span in Span #2 - Approach Span



{ per track

$M_{LL\ per\ girder} = (131.5 \times 9.12 - 65.75 \times 5.83) \div 2 = 407.98$ ft Kips

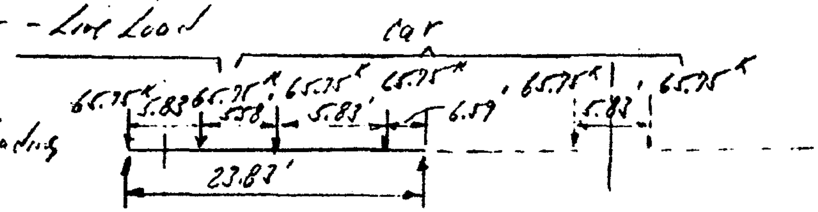
$Impact = \frac{100}{S} + 40 - \frac{3L^2}{1600}$ $S = 6.0'$, $L = 23.83'$

$= \frac{100}{6.0} + 40 - \frac{3 \times 23.83^2}{1600} = 16.66 + 40 - 1.06 = 55.6\ \%$

Total $M_{LL + impact} = 407.98 \times 1.556 = 634.82$ ft^k

Shear - Live Load

Car loading



R_L R_L

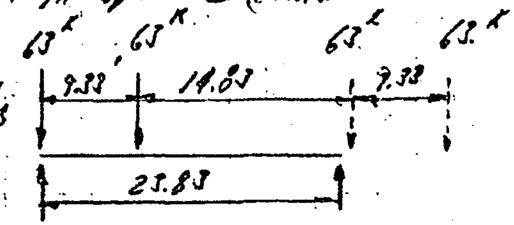
$= 65.75^k$
$65.75 \times 18.0/23.83 = 49.66$
$65.75 \times 12.42/23.83 = 34.26$
$65.75 \times 6.59/23.83 = 18.18$
$R_{L\ Total} = 167.85^k$

* $R_{max} = 167.85/2 \times 1.556 = 130.6^k/girder$

* Impact reduction factor helps when using diesel rather than steam.

Simple Span in Span #2 (Cont.)

Engine Loading



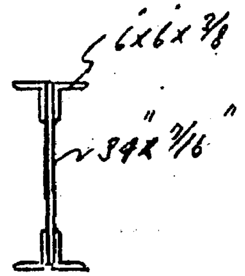
R_n less than car loading (by inspection)

Conclusion:

For simple span design check in Span #2 the live load rail moment is 27% greater than the assumed original design moment (634.82'K > 499'K quick analysis). Regarding shear the heavier loading with a different axle [illegible] products a <u>maximum</u> <u>live load</u> <u>shear</u> greater than the original (130.6^K versus 100.4^K ← assume by quick analysis

Design Check 23.83' span

M_{LL} = 635.00'K
M_{DL} = 200.00 (2,000'K x .1) scaled from original
Design M = 835.00'K



Moment of Inertia

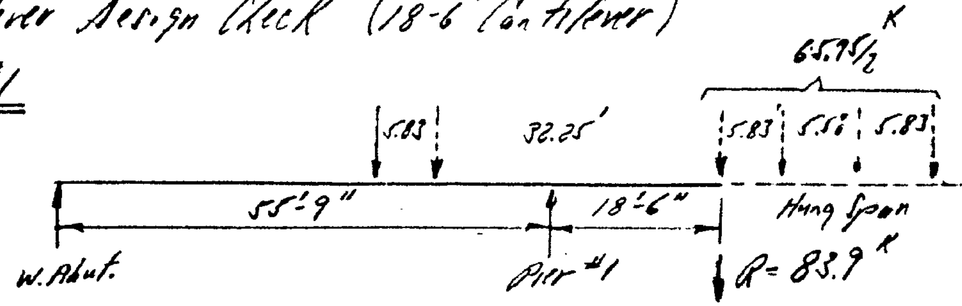
web I = 1433.0 in^4
Ls 2x30.8 = 61.6
Ad² 2x8.7x15.5² = 4,180.0
5674.6 in^4

Does not include moment from truck? Not necessary

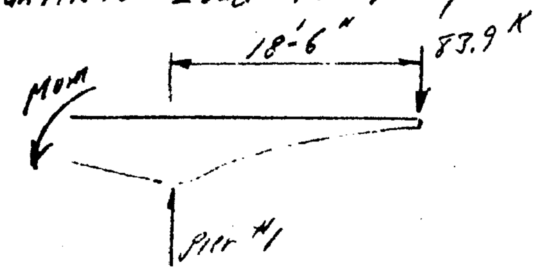
[illegible]

Cantilever Design Check (18'-6" Cantilever)

Position #1



Cantilever Load - Free Body



(Diesel/Impact)

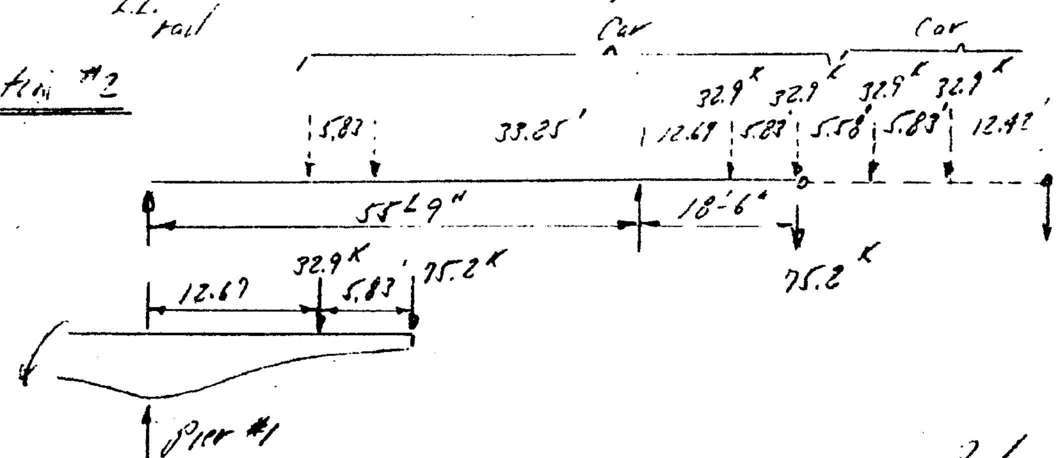
$$\text{Impact} = \frac{100}{6.0} + 40 - \frac{3 \times 18.5^2}{1600}$$

$$= 16.66 + 40 - .64$$

$$= 56\%$$

$$\text{Moment}_{L.L.\,rail} = 83.9 \times 18.5 \times \underset{\text{impact}}{1.56} = 2{,}421^{'K}$$

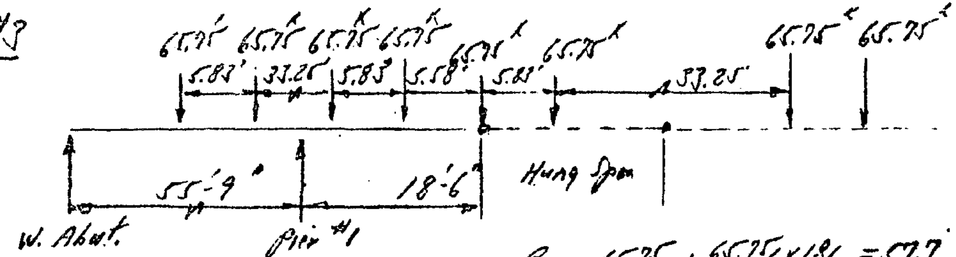
Position #2



$$\text{Mom}_{LL\,rail} = (75.2^K \times 18.5 + 32.9^K \times 12.67)\,1.56 = 2{,}820 \text{ ft Kips}$$ ← Rules

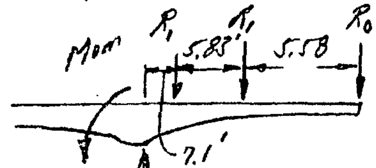
Cantilever Design Check (18'-6")

Position #3



$R_0 = 65.75/2 + 65.75/2 \times 18/23.83 = 57.7$

Cantilever Load - Free Body

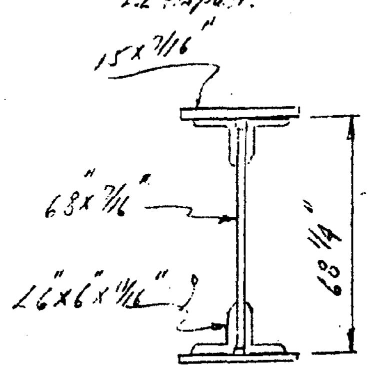


$R_1 = 65.75/2 = 32.8^k$ wheel

diesel impact

$Mom = [57.7^k \times 18.5 + 32.8^k \times 12.93 + 32.8^k \times 7.1]\,1.56 = 2689^{1k}$

LL + impact



Moment of Inertia

Web Pl.	I_o	=	11,464
6x6x11/16 Flg. Ls	2 x 48.3	=	97
Ad^2_{Ls}	$14.2 \times 32.39^2 \times 2$	=	29,795
Cov. Plate		=	"
Ad^2_{Pl}	$6.56 \times 34.34^2 \times 2$	=	15,471
			56,827 in^4

Mom. Diagram

$Mom_{Total} = 2{,}689 + 2{,}000^{1k} \times .45 = 2{,}689 + 900 = 3{,}589^{1k}$

*no truck moment included

$f_s = \dfrac{3{,}589 \times 12 \times 34.57}{56{,}827} = 26.2\ ^k/in^2 > 24.0\ ^k/in^2$ design

* Truck and train cannot apply loads at the same time to track girder. Original design

SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

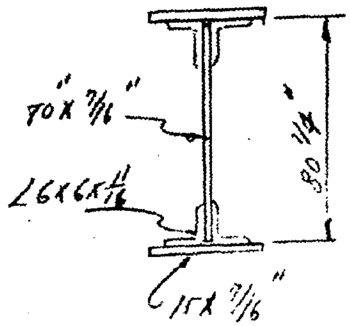
JOB: Rail Study SSRPA. NOTES BY: A.J.S. DATE: 9/30/87 PAGE NO. V

Bridge Capacity - Rail Study CHECK BY: DATE:

Pier #2 Cantilever Section Check (Same Moment as Pier #1

Moment Dead Load & Live Load Total = 3,720 ft Kips

Section @ Pier #2

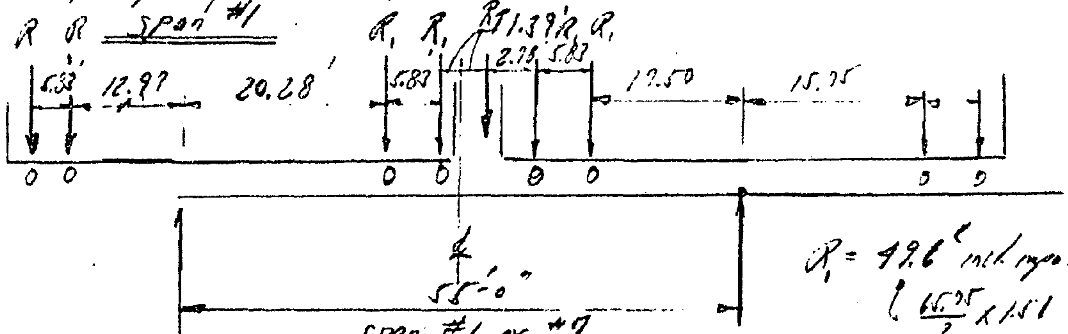


Moment of Intertia

web ℞	I_{ϕ}	=	18,667
Flge L1	2 x 48.3	=	97
Ad^2 L1	$14.2 \times 38.39^2 \times 2$	=	41,856
Cov. ℞ Ad^2 ℞	$6.56 \times 40.57^2 \times 2$		21,350
			81,770 in^4

$$f_s = \frac{3{,}720 \times 12 \times 40.56}{81{,}770} = 22.1\ K/in^2 > 24.0\ K/in^2$$

Girder G-1 at Pier #2 satisfies stress requirements for cantilever moment. Positive area



$R_1 = 49.6^k$ incl. impact

$\left(\frac{65.75}{2} \times 1.51\right)$

$R_L = \overbrace{4 \times 49.6}^{R_T} \times 26.11 / 55 = 94.2^k$

$R_R = 4 \times 49.6 \times 28.89 / 55 = 104.2^k$

Impact $= \frac{100}{6.0} + 40 - \frac{3 \times 55^2}{1600}$

$= 16.66 + 40 - 5.7 = 51\%$

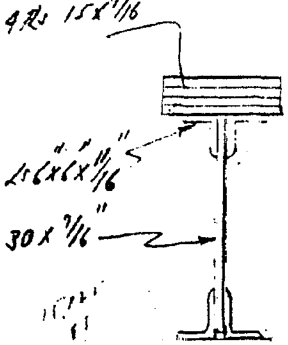
Pt. Zero Shear @ 2nd wheel from left support

$M_{LL+impact} = 94.2 \times 26.11 - 49.6 \times 5.83$

$= 2460 - 289 = 2170$ ft Kips — Conservative Moment since load on Cantilever neglected.

M_{DL} from diagram $= 2{,}000{,}000 / 1000 \times .2 = 400$ ft Kips

$M_{om\ Total} = \overline{2570}$ ft Kips



Moment of Inertia

web I	$= 1175\ in^4$
Ls 6x6x5/8 2 x 48.3	= 97
$Ad^2 = 2 \times 14.2 \times 13.39^2$	= 5092
PLs $15 \times 1.75^3/12 \times 2$	= 14
Ad^2 $26.4 \times 2 \times 16.01^2$	$= 13{,}533$

SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

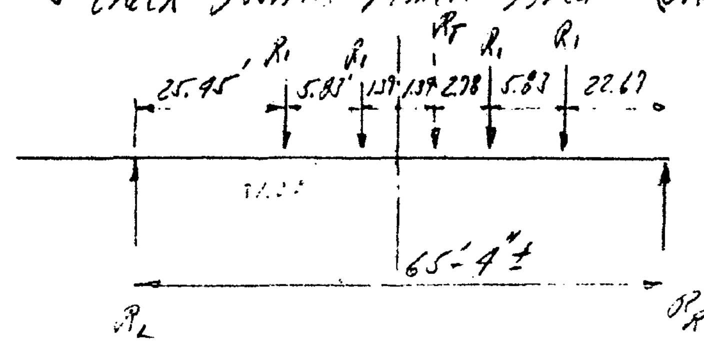
JOB: Rail Study NRPA — NOTES BY: R.T.G. — DATE: 10/9/83 — PAGE NO. 10

Bridge Capacity - Rail Study — CHECK BY: — DATE:

Approach Span #1 - Positive Moment

$$f_s = \frac{2570 \times 12 \times 16.87}{19,931} = 26.10^k/in^2 > 24.0^k/in^2$$

Span #3 Check Positive Moment Area (over from #5)



$$Impact = \frac{100}{6.0} + 40 - \frac{3 \times 65}{1600} = 43\%$$

$$R_1 = \frac{65.35}{2} \times 1.43 = 49.0$$

$$R_L = 4 \times 49.0 \times 31.28 / 65.33 = 93.8^k$$

$$R_R = 4 \times 49 \times 34.04 / 65.33 = 102.2^k$$

At zero shear @ 2nd wheel from left support

$$M_{LL+impact} = 93.8 \times 31.28 - 49.0 \times 5.83$$

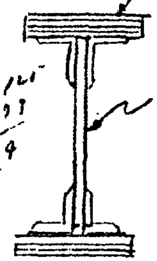
$$= 2934 - 286 = 2648 \text{ ft kips}$$

$$M_{DL \text{ from diagram}} = 2,000,000/1000 \times .425 = \underline{850}$$

$$3,498 \text{ ft Kips}$$

Span #3 Positive Moment Check (Cont.)

4 PLs 15" x 7/16"



40 x 7/16"

$\frac{40.25}{2}$ 20.125
1.73
18.4

~140.25 20.125
.88
21.015

Moment of Inertia

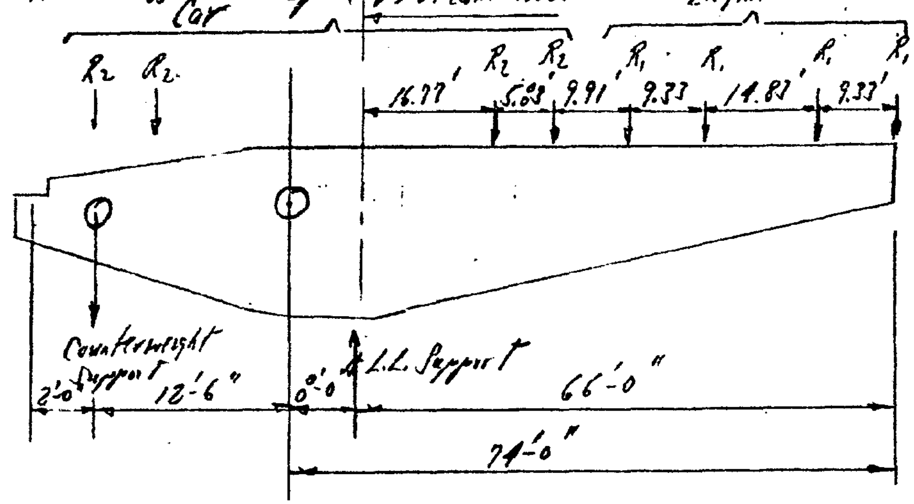
Web PL	=	2,333 in^4
Ls 6x6x 3/4 (2x24.2)x2	=	97
Ad^2 - 2x14.2 x 18.4^2	=	9,615
PLs 15 x 1.75^3/12 x2	=	14
Ad^2 26.3 x 2 x 21.01^2	=	23219
		35,278 in^4

$$f_s = \frac{3,498 \times 12 \times 21.88}{35,278} = 26.1 \text{ k/in}^2 > 24.0 \text{ k/in}^2$$

$$\% \text{ overstress} = \frac{26.1 - 24.0}{24} \times 100 = {}^{*}9\% \text{ D.L. + Train Load}$$

* with truck loading should be approx 15%

Position #1 Bascule Span at of Cantilever



$R_1 = 63 \times 16.75/21 = 50.25^k$ axial reaction to interior Girder from Engine

$R_2 = 65.75 \times 16.75/21 = 52.5^k$ " " " " " Box or Hopper car

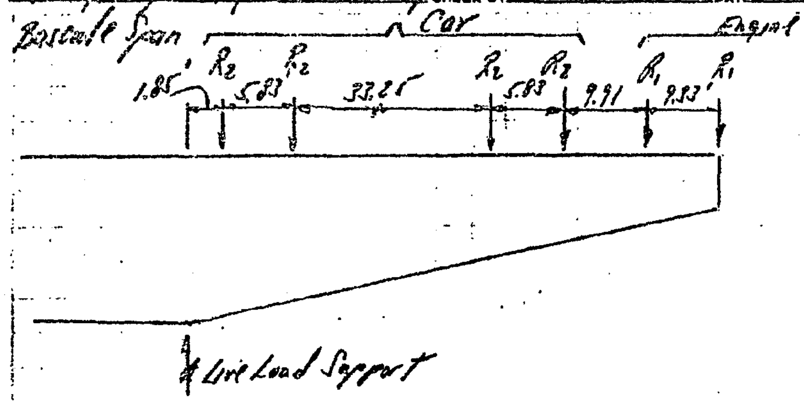
$$Impact = \frac{100}{21} + 40 - \frac{3 \times 66^2}{1600}$$

$$= 4.76 + 40 - 8.17 = 37\%$$

Cantilever Live Load Moment.

$$M_{LL} = 52.5 \times 16.77 = 880$$
$$52.5 \times 22.60 = 1187$$
$$50.3 \times 32.51 = 1635$$
$$50.3 \times 41.84 = 2104$$
$$50.3 \times 56.67 = 2851$$
$$50.3 \times 66.00 = \underline{3320}$$
$$11,977 \text{ ft Kips}$$

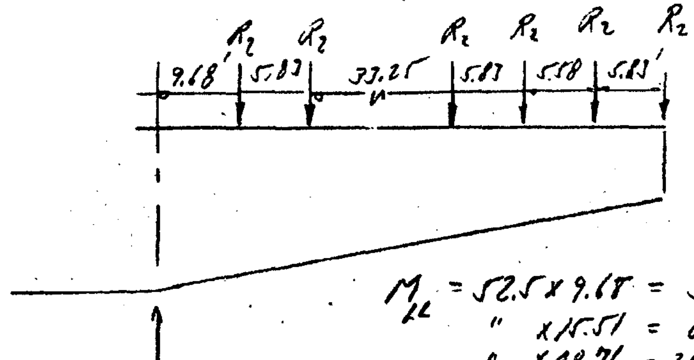
$M_{LL+impact} = 11,977 \times 1.37 = 16,408$ ft Kips



Position #2 Bascule Span

Cantilever Live Load Moment

M_{LL} = 52.5 x 1.85 = 97
52.5 x 7.68 = 403
52.5 x 40.93 = 2149
52.5 x 46.76 = 2455
50.3 x 56.67 = 2850
50.3 x 66.00 = 3320
11,274 ft Kips x 1.37 = 15,445 ft Kips



Position #3 Bascule Span

M_{LL} = 52.5 x 9.68 = 508
" x 15.51 = 814
" x 48.76 = 2560
" x 54.59 = 2866
" x 60.17 = 3159
" x 66.00 = 3465
Mom Total = 13,372 ft Kips

M[illegible] = 13,372 x 1.37 = 18,320 ft Kips ← Rules

SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

JOB Rail Study S.S.R.P.A. NOTES BY R.J.G. DATE 8/10/82 PAGE NO. BG-7

Bridge Capacity - Rail Study CHECK BY ______ DATE ______

Bascule Span

Assume Calculation for Bascule Dead wt

Open Grating 2½" x 3/16" brg bars - 20#/ft² ±

(Stringers 12 I 31.8 with ST 10 I 42.5) [5 req.]
(Stringer for rail 18 I 54.7) [2 req]
Transv. supports for grating 7 [14.75 10 req between F.B's

Rail supports " " 7 [14.75

Total Dead Load between two bascule girders

12 I 31.8 stringers	= 31.8 x 12.92 x 5	= 2054#
~~18 I 54.7 stringers under rail~~	~~= 54.7 x 12.92 x 2~~	~~= 1413~~
Support over stringers ST 10 I 42.5	- 42.5# x 12.92' x 5	= 2746
for transv. grating support		
Transv. grating support 7 [14.75	= 14.75 x 23.00 Total x 10	= 2913
Rail support 7 [14.75	14.75 x 5.0 x 10	= 737
Stringer between center bascule 12 I 31.8	31.8 x 12.92 x 1	= 411
Grating	20#/ft² x 12.92 x 23.0	= 5943
	Total wt per panel	= 14,804

2 Rails 100# $100 \times 12.92 \times 2 \times 16.75/21$ = 2,061#

18 I 54.7 Stringer under rail $54.7 \times 12.92 \times 2 \times 16.75/21$ = 1,127#

Bascule Span

Assumed Floor Beam Weight

Top angles ∠s 3½x3½x3/8	8.5# x 2 x 20.66	=	351#
web Pl Top Chord 20x3/8	25.5# x 1 x 20.66	=	527
Bot Chord Angles ∠s 5x3½"x3/8"	10.4# x 2 x 20.66	=	430
web members 2∠s 5"x3½"x3/8" 80 lin. ft	10.4 x 2 x 80	=	1664
Gussets etc		=	200
			3,172#

Assumed Floor Beam Solid Diaphragm

web 41x3/8x9'-6"	52.3# x 9.5	=	497
∠s 6"x3½"x5/16"	15.3 x 8 x 9.5	=	1163
			1,660#

Assume Load Reaction at Floor Beam Locations

Main deck Framing = 14,804/2	=	7,402#
Reaction from railwt & supports 2061# + 1127#	=	3188#
Wt from Floor Beam 3,172/2	=	1586#
Wt from Solid Floor Bm = 1660/2	=	830#
		13,006#
Add 10%		1300
		14,306#

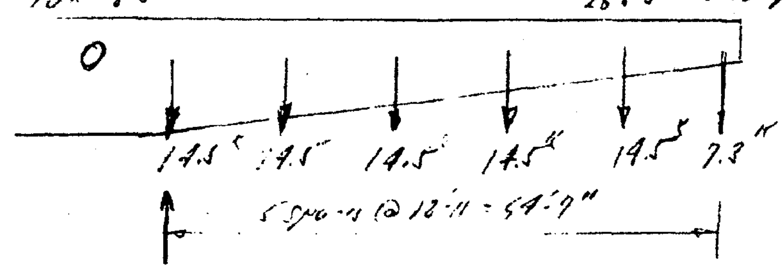
use 14,500#

Average wt of Bascule Girder

web ℞	102" x 5/8"	217#/ft x 26	= 5642
Ls	8x8x3/4	38.9	
Cover ℞	18 x 5/8	38.3	
	18 x 3/4	45.9	
	18 x 3/4	45.9	
	18 x 3/8	23.0	
		153.1 x 26	= 3978
			9,620 # Tr. panel

web ℞	63 x 1/2	107 x 40.5 = 4334	
Ls	7x7x3/4	38.9	=
Cover ℞	18 x 3/4	45.9	
	18 x 3/8	23.0	
		107.8 x 40.5	= 4365
			8,699 # Tr. panel

web ℞	82" x 7/16	77.4 x 14.33	- 1109
Ls	8x8x3/4	38.9 x 14.33	- 557
Cov ℞	18 x 3/4, 18 x 3/8	68.9 x 14.33	= 987
			2653 end panel



7.16
14.38

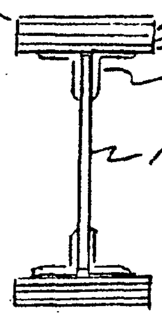
Dead Load Moment

From Girder $(9.62 \times 1.10\%) \times 13.0' =$ 137.0 ft Kips
$(8.70 \times 1.10\%) \times 38.8 =$ 371.3 " "
$(2.65 \times 1.10\%) \times 58.8 =$ 171.4 " "
679.7 ^{1K}

From Deck System thru Floor Beams

$14.5 \times 5 \times (12.92 \times 2) = 1873.4$
$7.3 \times 64.5 = 470.9$
2344.3 ^{1K}
Total Dead Load Moment 3,024.0 ^{1K}

Section Modulus at Live Load Support Location



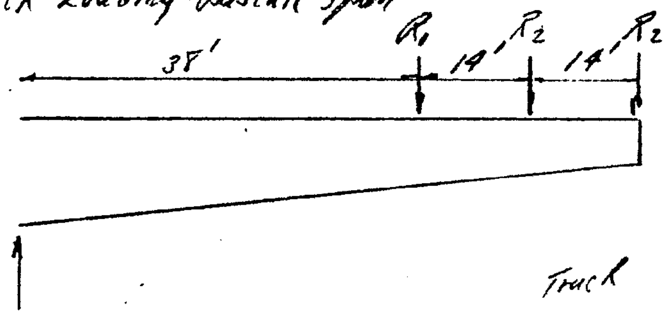
web I = 111,827
Ls 56.3 x 2 = 113
Ad^2 $16.9 \times 63.77^2 \times 2$ = 134,024
$13.5 \times 65.13^2 \times 2$ = 114,532
$13.5 \times 65.88^2 \times 2$ = 117,184
$11.25 \times 66.51^2 \times 2$ = 99,530
$11.25 \times 67.14^2 \times 2$ = 101,424
I_{gross} = 678,634 in^4

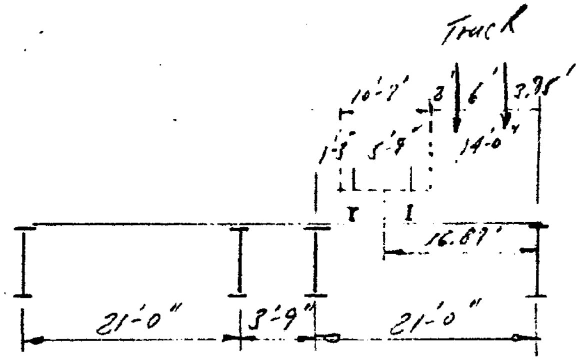
SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

JOB: Rail Study, S.F.R.P.A. NOTES BY: R.T.G. DATE: 4/29/83 PAGE NO: BG-7

Bridge Capacity Rail Study CHECK BY: DATE:

HS20-44 Truck Loading - Bascule Span





Percentage of truck load to interior bascule girder $= \frac{6.75}{21} = .32$

$R_1 = 8.0^K \times .32 = 2.56^K$

$R_2 = 32.0^K \times .32 = 10.24^K$

$\text{Impact} = \frac{50}{56+125} = .26$

$M_{LL+Impact} = (\overset{97}{2.56^K \times 38} + \overset{532.}{10.24 \times 52} + \overset{676}{10.24 \times 66})1.26$

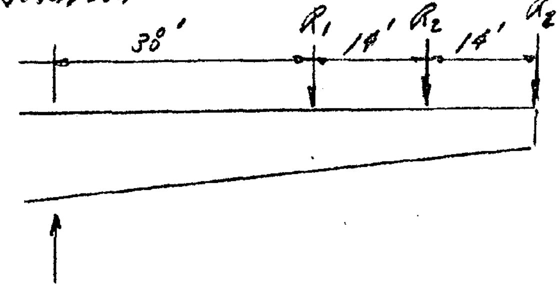
$= 1645 \text{ ft Kips}$

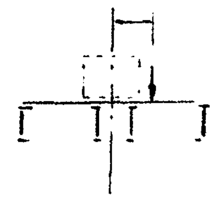
Total Moment on Bascule Girder Supporting train loads $\left. \right\} = 18,320 + \overset{\text{Train}}{1645} + \overset{\text{Truck}}{3024}$

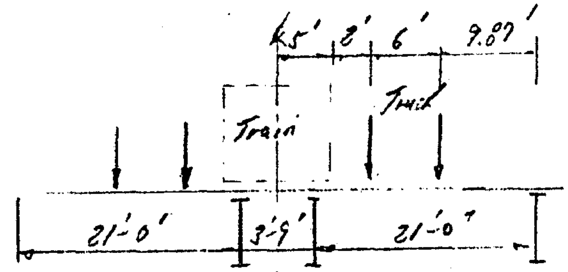
$= 22,989 \text{ ft Kips}$

$f_s = \frac{22,989 \times 12 \times 67.5}{678,634} = 27.4 \ ^K/in^2$ gross section

Truck Loading HS 20-44 with One track at ℄
Alternate Solution







Percentage of truck load to interior bascule $= \frac{12.87}{21} = .61$

$R_1 = 8.0^k \times .61 = 4.88^k$ Impact $= \frac{50}{66+125} = .26$

$R_2' = 32.0 \times .61 = 19.52^k$

$M_{LL+impact} = (\overset{185}{4.88 \times 38} + \overset{1015}{19.52 \times 52} + \overset{1288}{19.52 \times 66})1.26 = 3135$ ft Kips

Total Moment

$M_{L.L.+impact_{Train}} = 18,320 \times \frac{32.9}{52.5} = 11,480$ ft Kips ($65.75/2$)

$M_{LL+impact\ truck}$ = 3,135 ft Kips

$M_{D.L.}$ = 3,024 ft Kips

17,639 ft Kips

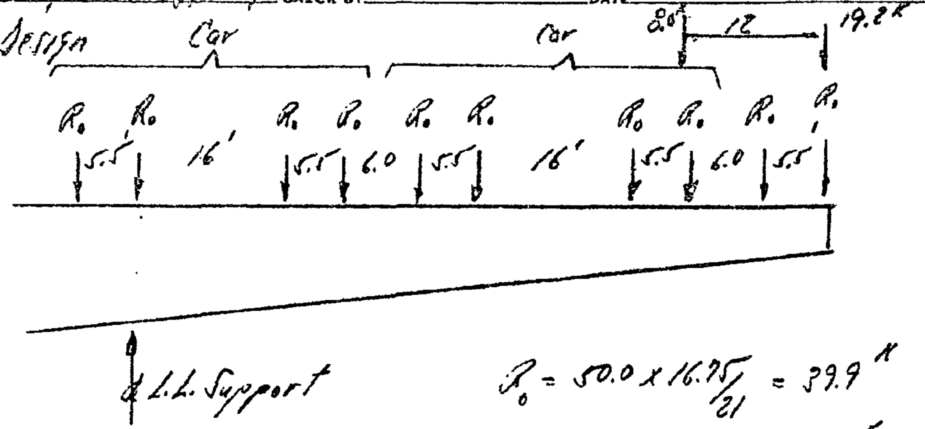
$f_b = \frac{17,639 \times 12 \times 67.5}{} = 21.1$ K/in² < 29.0 K/in² allowable

SEELYE STEVENSON VALUE & KNECHT — CONSULTING ENGINEERS

JOB: Rail Study S.C.R.R.A — NOTES BY: R.J.G. — DATE: 1/29/83 — PAGE NO. BG-9

Bridge Capacity Rail Study — CHECK BY: — DATE:

Original Design Check



$R_0 = 50.0 \times 16.75/21 = 39.9^K$

$R_1 = 24.0 \times 16.75/21 = 19.2^K$

$R_2 = 10.0 \times 16.75/21 = 8.0$

Cantilever Live Load Moment

Train

$M_{LL} = 39.9 \times 16 = 638$

$\quad \text{"} \times 21.5 = 858$

$\quad \text{"} \times 27.5 = 1097$

$\quad \text{"} \times 33.0 = 1317$

$\quad \text{"} \times 49.0 = 1955$

$\quad \text{"} \times 54.5 = 2175$

$\quad \text{"} \times 60.5 = 2414$

$\quad \text{"} \times 66 = 2633$

13,087 ft Kips

Truck

$M_{LL} = 19.2 \times 66 = 1267$

$8.0 \times 54 = 432$

1699 ft Kips

Mom L.L. Imp = 13,087 × 1.06 = 13,872 ft Kips

Mom LL Truck = 1699

Mom Dead Load = 3,024

18,595 ft Kips

$f_s = \dfrac{18{,}595 \times 12 \times 67.5}{678{,}634} = 22.2\ ^K/_{in^2} < 29.0\ ^K/_{in^2}$ design allowable

Crude estimates associate capital and operating costs with rehabilitation of the existing Tomlinson Bridge and with five service options described in the text. Unit costs are drawn from recent analogous construction experience and are advanced by the Regional Planning Agency--not be Seelye, Stevenson, Value and Knect.

Capital Costs

Order of magnitude costs consistent with planning needs and capabilities reflect:

- new single track railroad structure over land--$1,500 per linear foor or $300 per square foot of deck. Alternative B (an inland approach from the east shore) requires extensive structure to maintain an acceptable grade over Quinnipiac Avenue and Ferry Street. The alignment transitions from a former rail right-of-way to a river front location via the Quinnipiac River Industrial Park. Costs reflect a double girder structure, a five foot wide deck and the necessity of a 90-foot long clear span over Ferry Street. Ferry Street Bridge abutments and severe grade proclude more limited structure extending only over Quinnipiac Avenue.

- new track on fill with retaining walls--$950 per linear foot for a single track facility. Costs reflect a transition from structure to level grade through wetland areas adjacent to the river, fill averaging 4 feet deep and $200 per linear foot for new track in place (exclusive of switching).

- bridge over water--$20,000 per linear foot for an initial 600-foot crossing and $12,500 per foot thereafter. Costs reflect causeway and double leaf bascule construction necessary to provide one track service, span deep water and bridge widths represented by the Quinnipiac River.

- new and/or improved track--$225 per linear foot. Costs reflect 115 pound rail in place, ballast, tire renewal and limited switching capabilities.

Annual Operating Costs

Recent Conrail experience permits broad assessment of maintenance and operating costs.(1) Annual operating costs include:

- track and switch maintenance--$12,300 per mile of yard and spur tracks.

---

(1) Six-year old Conrail unit costs are drawn from: Conrail, Belle Dock Economic Study prepared for C. R. McKenna by E.G. Barske (November 2, 1978). Unit costs are inflated at 7.5 percent per annum over the 1978--1984 period.

- locomotive operating and maintenance (mechanical)--$11.06 per operating hour; and
- direct hourly salary costs for a basic four man switching crew (straight time at 40 hours per week)--$48.33.

Projected Costs

Tables D-1 through D-7 associate capital operating costs with eight rail options ranging from maintenance of current Tomlinson Bridge rail capabilities through an inland approach. Cost estimates:

- pro-rate joint capital, maintenance and operating costs associated with the East Street spur relative to current east and west shore traffic (freight car movements); i.e. about 15 percent of joint costs are associated with the east shore. Later illustrations alter the initial cost allocation scheme.
- identify costs wholly associated with east shore service.
- anticipate the full range of capital costs inherent in a forty year standard "project life."
- draw right-of-way costs from City of New Haven Tax Assessor's materials (See Appendix E). A 2.5 to 1 market-to-assessed value ratio is assumed correlate with the limited sale of waterfront property (a limited "comparables" base for the assessor) and general experience.

An Investment Decision

Tables D-8 through D-28 address the relative attractiveness of east shore investment alternatives. Long term costs of transporting freight from the Cedar Hill Yards to the east shore are assessed at various traffic levels. Capital, maintenance and operating cost streams identified in Tables D-1 through D-7 are:

- discounted at current 10 percent public sector long term borrowing rates over a 42 year project. A two-year design period (1984--1985), a one-year right-of-way acquisition period (1985) and a one-year construction period (1986) are assumed for illustrative purposes. New operational capabilities are assumed to come "on line" in 1987.
- associated with current 600 car east shore annual movement levels (15 percent of annual Belle Dock spur traffic) and with both 2,000 and 4,000 car per year east shore flows. Two thousand car per annum inputs assume: (1)that a 16 car per day east shore movement requires two movements from Belle Dock via the inland route in view of 10 car grade-related constraints; (2)west shore traffic remains fixed as 3,400 cars per annum; and (3)two movements per day from Cedar Hill to Belle Dock are necessary in view of a 20 car (approximate) per train maximum and a 30 car per day demand.

evaluated in terms of the current discounted cost per 1,000 pounds of dry product (compacted scrap) and petroleum (No. 2 oil) transported to or from the east shore (New Haven Terminal). Scrap is assumed to be carried in a 50 foot, 100-ton gondola with a 100 ton effective payload -- though limited to 137,800 pounds by current Tomlinson Bridge weight restriction. Number 2 oil is assumed to be carried in a standard 23,000 gallon tank car with an effective 188,700 pound payload. Current Tomlinson Bridge weight restrictions limit number 2 oil loadings to 125,700 pounds or 15,700 gallons.

Neither rail operating costs nor highway demand makes current operating constraints acceptable for mid to high level rail traffic. Limited capital costs clearly make operation via an enhanced Tomlinson Bridge a relatively attractive alternative. Inland route service fairs well from a purely economic perspective but, as noted in the text, presents unacceptable environmental impacts. High construction and right-of-way costs associated with new Quinnipiac River crossings diminish their attractiveness (Table D-29).

Table D-1

TOMLINSON BRIDGE
CURRENT CAPABILITIES

Key Elements

1. Single Car 200,000 movements on the Tomlinson Bridge. A 140,000 pound (16,000 gallon) payload for a standard 23,000 gallon tank car carrying petroleum.

2. All bridge investment associated with highway facilities -- no change in rail capacity.

3. New East Street and east shore track required in 1994.

4. Renew all rail by 1994.

Table D-1 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
o Renew Main line to Belle Dock track (1994) 4,700 feet, $225 per l.f.	$1058	$899	$159
o Renew Belle Dock to East Shore track (1994) 4,500 feet, $225 per l.f.	1012	--	1,012
Annual (000's)			
o Track maintenance Main line to Belle Dock 4,700 feet, $2.33 per l.f.	11.0	9.3	1.7
o Track maintenance Belle Dock to East Shore 4,500 feet, $2.33 per l.f.	10.5	--	10.5
Per hour (engine and crew)			
o Cedar Hill to Belle Dock 36 min, %49.33 per hour[(1)]	36	31	5
o Bell dock to East shore (3 cars per day) or 122 minutes, 2.03 hours, $59.39 per hour[(2)]	120	--	120

(1) Includes 15 minute air brake adjustment and/or switching at Bell Dock. Cedar Hill - to - East Street Span at 15 mph (14,000') and main line - to - Belle Dock at 10 mph (4,700').

(2) One car at a time with 15 minute at either end to uncouple and/or couple. Here assume three cars per day or 600 cars annually -- about level of late 1970's.

Table D-2

TOMLINSON BRIDGE
ENHANCED CAPABILITIES

Key Elements

1. 263,000 pound cars in 10-12 car units.
2. $5.0 million marginal Bridge cost to reflect heavy, multi-car train requirements if pursued in the context of a comprehensive Bridge rehabilitation project.

Table D-2 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
o Renew main line to Belle Dock track per Table D-1 (1994)	$1,058	$899	$159
o Renew East Shore track and West Shore approaches (1986)	743		743
o Marginal cost of Bridge improvements (1986)	5,000		5,000
o R-O-W acquisition costs (1985)	54		54
o Design (1984)	573		573
o Construction engineering (1986)	861		861
Annual (000's)			
o Track maintenance Main line to Belle Dock (per Table D-1)	11.0	9.3	1.7
o Track maintenance Belle Dock to East Shore (per Table D-1)	10.5	--	10.5
Per hour (engine and crew)			
o Cedar Hill to Belle Dock	36	31	5
o Belle Dock to East Shore[1]	48	--	48

[1] 24 minutes one way. Allow for return to Belle Dock.

Table D-3

ALTERNATE A
IMMEDIATELY SOUTH OF TOMLINSON BRIDGE

Key Elements

1. 10-12 Car, 263,000 pound movements possible

Table D-3 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
Bridge and approaches			
o Design (1984)	$1,393	$ --	$1,393
o R-O-W (1985)	154	--	154
o Construction (1986)(1)	15,313	--	15,313
Rail			
o Belle Dock to East Shore (1986) (excluding bridge)	709	--	709
o Renew Main line to Belle Dock (1994)	1,058	599	159
Annual Track Maintenance (000's)			
o Main line to Belle Dock	11.0	9.3	1.7
o Belle Dock to East Shore	10.5	--	10.5
Per Hour (engine and crew)			
o Cedar Hill to Belle Dock	36	31	5
o Belle Dock to East Shore(2)	48	--	48

(1) Includes construction supervision.

(2) 10 Car consist, 9 minute run plus 15 min. coupling/uncoupling.

Table D-4

ALTERNATE B
INLAND ROUTE

Key Elements

1. Reuse of abandoned three mile right-of-way and relocation of "Jet Lines."
2. Extensive structure adjacent to Ferry Street.
3. Extensive movement to East Shore. No joint costs with East Street spur.

Table D-4 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
Inland Route			
o Design (1984)	$641	$ --	$641
o R-O-W (1985)	1,528		1,528
o Construction (1986)	4,861		4,861
o Rail (1986)	1,980		1,980
o Relocate pipeline (1986)	530		530
East Street Spur			
o Renew Main Line to Belle Dock rail (1994)	1,058	1,058	
Annual (000's)			
o Inland route to East Shore	14.2		14.2
o Main line to Belle Dock	11.0	11.0	
Per Hour (engine and crew)			
o Cedar Hill to Belle Dock	36	26	
o Cedar Hill to East Shore	74		74

(1) 9 minutes between Cedar Hill Yards and East Haven "cut-off" from the main line, 8 minutes from the "cut-off" to Forbes Avenue--Waterfront Street, 5 minutes from Forbes Avenue--Waterfront Street to New Haven Terminal and 15 minutes uncoupling/coupling. Allow for empty return trip.

Table D-5

ALTERNATE C
1000 FEET SOUTH OF TOMLINSON BRIDGE

Key Elements

1. Multi-car 263,000 pound car consists.

2. Expensive shorefront acquisition of Conrail and Gulf Oil property.

3. Span Quinnipiac River at Wide Point.

Table D-5 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
Bride and approaches			
o Design (1984)	$2,189		$2,189
o R-O-W (1985)	1,167		1,167
o Construction (1986)	25,170		25,170
Rail			
o e/o Bridge (2,800 l.f) (1986)	630		630
o Belle Dock to West Shore (1986)	225		225
o Renew from Main line to Belle Dock (1994)	1,058	$899	159
Annual Track Maintenance (000's)			
o Main line to Belle Dock	11.0	9.3	1.7
o Belle Dock to West Shore	2.3		2.3
o e/o Bridge	6.5		6.5
Per Hour (engine and crew)			
o Cedar Hill to Belle Dock	36	31	5
o Belle Dock to East Shore (1)	42		42

(1) 3,500 feet, 7.5 mph or 6 minutes plus 15 minute coupling/uncoupling at New Haven Terminal. Belle Dock uncoupling included with Cedar Hill-to-Belle Dock cost. Allow for empty return to Belle Dock.

Table D-6

ALTERNATE D
MANUFACTURERS SPUR

Key Elements

1. Multi-car trains.

2. 263,000 pounds per car.

3. Alternative Quinnipiac Park

4. New track and structure at north end of spur to move multi-car trains to/from Main line.

Table D-6 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
Manufacturers Spur			
o New rail between Castle Street and Quinnipiac River (4,075 ft) (1986)	$917	--	$917
o Bridge and approaches (1986)	15,753	--	15,753
o East Shore rail (2700 ft.) (1986)	608	--	608
o R-O-W (1985)	467	--	367
o New alignment at North end (1986)	1,500	--	1,500
o Design (1984)	1,878	--	1,878
o Construction engineering (1986)	2,817	--	2,817
East Street Spur			
o New rail Main line to Belle Dock (1994)	1,058	1,058	
Annual Track Maintenance (000's)			
o Main Line to Belle Dock	11.0	11.0	
o Manufacturers spur and East Shore	19.7		19.7
Per Hour (engine and crew)			
o Cedar Hill to Belle Dock	36	36	
o Cedar Hill to East Shore(1)	74		74

(1) 13,500 ft. Cedar Hill to relocated manufacturers spur at 15 mph, 4,775 ft. Main line to Quinnipiac River at 10 mph, 1200 feet Bridge and approaches at 7.5 mph, 2,000 feet at 5 mph to New Haven Terminal. 15 minutes coupled/uncoupled or 37 minutes. Allow for empty return to Cedar Hill.

Table D-7

ALTERNATE E
IMMEDIATELY NORTH OF TOMLINSON BRIDGE

Key Elements

1. Multi-car Trains.

2. 263,000 pounds per car.

3. Necessarily acquire Yale Boat House in view of limited clearance between existing bridge and building.

Table D-7 (cont'd)

Cost Element	Total	Allocated to East Street	Allocated to East Shore
Capital (000's)			
Bridge and approaches			
o design (1984)	$1,481		$1,481
o R-O-W (1985)	801		801
o Construction (1986)	17,035		17,035
Rail			
o Renew Main line to Belle Dock (1994)	1,058	899	159
o East Shore (1986)	653		653
Annual Track Maintenance (000's)			
o Main line to Belle Dock	11.0	9.3	1.7
o Belle Dock to East Shore	8.6	--	8.6
Per Hour (engine and crew)			
o Cedar Hill to Belle Dock	36	31	5
o Belle Dock to East Shore[1]	48	--	48

[1] Per Table D-3

Table D-8

Net Present Cost
Tomlinson Bridge--Current Rail
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984		12200	31250	43450		
1985		12200	31250	43450		
1986		12200	31250	43450		
1987		12200	31250	43450		
1988		12200	31250	43450		
1989		12200	31250	43450		
1990		12200	31250	43450		
1991		12200	31250	43450		
1992		12200	31250	43450		
1993		12200	31250	43450		
1994	1171000	12200	31250	1214450		
1995		12200	31250	43450		
1996		12200	31250	43450		
1997		12200	31250	43450		
1998		12200	31250	43450		
1999		12200	31250	43450		
2000		12200	31250	43450		
2001		12200	31250	43450		
2002		12200	31250	43450		
2003		12200	31250	43450		
2004		12200	31250	43450		
2005		12200	31250	43450		
2006		12200	31250	43450		
2007		12200	31250	43450		
2008		12200	31250	43450		
2009		12200	31250	43450		
2010		12200	31250	43450		
2011		12200	31250	43450		
2012		12200	31250	43450		
2013		12200	31250	43450		
2014		12200	31250	43450		
2015		12200	31250	43450		
2016		12200	31250	43450		
2017		12200	31250	43450		
2018		12200	31250	43450		
2019		12200	31250	43450		
2020		12200	31250	43450		
2021		12200	31250	43450		
2022		12200	31250	43450		
2023		12200	31250	43450		
2024		12200	31250	43450		
2025		12200	31250	43450		
2026		12200	31250	43450		
Total	1171000	524600	1343750	3039350		
Net present cost				837715.5	.2412386	2.117368

Table D-9

Net Present Cost
Tomlinson Bridge--Heavy Rail
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	573000	12200	31250	616450		
1985	54000	12200	31250	97450		
1986	6604000			6604000		
1987		12200	13250	25450		
1988		12200	13250	25450		
1989		12200	13250	25450		
1990		12200	13250	25450		
1991		12200	13250	25450		
1992		12200	13250	25450		
1993		12200	13250	25450		
1994	159000	12200	13250	184450		
1995		12200	13250	25450		
1996		12200	13250	25450		
1997		12200	13250	25450		
1998		12200	13250	25450		
1999		12200	13250	25450		
2000		12200	13250	25450		
2001		12200	13250	25450		
2002		12200	13250	25450		
2003		12200	13250	25450		
2004		12200	13250	25450		
2005		12200	13250	25450		
2006		12200	13250	25450		
2007		12200	13250	25450		
2008		12200	13250	25450		
2009		12200	13250	25450		
2010		12200	13250	25450		
2011		12200	13250	25450		
2012		12200	13250	25450		
2013		12200	13250	25450		
2014		12200	13250	25450		
2015		12200	13250	25450		
2016		12200	13250	25450		
2017		12200	13250	25450		
2018		12200	13250	25450		
2019		12200	13250	25450		
2020		12200	13250	25450		
2021		12200	13250	25450		
2022		12200	13250	25450		
2023		12200	13250	25450		
2024		12200	13250	25450		
2025		12200	13250	25450		
2026		12200	13250	25450		
Total	7390000	512400	592500	8494900		
Net present cost				5845343.	1.206379	10.49358

Table D-10

Net Present Cost
Alternate A--Immediately South of Tomlinson Bridge
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per pounds	000 gallons
1984	1393000	12200	31250	1436450		
1985	154000	12200	31250	197450		
1986	16022000			16022000		
1987		12200	13250	25450		
1988		12200	13250	25450		
1989		12200	13250	25450		
1990		12200	13250	25450		
1991		12200	13250	25450		
1992		12200	13250	25450		
1993		12200	13250	25450		
1994	159000	12200	13250	184450		
1995		12200	13250	25450		
1996		12200	13250	25450		
1997		12200	13250	25450		
1998		12200	13250	25450		
1999		12200	13250	25450		
2000		12200	13250	25450		
2001		12200	13250	25450		
2002		12200	13250	25450		
2003		12200	13250	25450		
2004		12200	13250	25450		
2005		12200	13250	25450		
2006		12200	13250	25450		
2007		12200	13250	25450		
2008		12200	13250	25450		
2009		12200	13250	25450		
2010		12200	13250	25450		
2011		12200	13250	25450		
2012		12200	13250	25450		
2013		12200	13250	25450		
2014		12200	13250	25450		
2015		12200	13250	25450		
2016		12200	13250	25450		
2017		12200	13250	25450		
2018		12200	13250	25450		
2019		12200	13250	25450		
2020		12200	13250	25450		
2021		12200	13250	25450		
2022		12200	13250	25450		
2023		12200	13250	25450		
2024		12200	13250	25450		
2025		12200	13250	25450		
2026		12200	13250	25450		
Total	17728000	512400	592500	18832900		
Net present cost				13749325	2.837627	24.68283

Table D-11

Net Present Cost
Alternate B--Inland Route
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	641000	12200	31250	684450		
1985	1528000	12200	31250	1571450		
1986	7371000	12200	31250	7414450		
1987		14200	18500	32700		
1988		14200	18500	32700		
1989		14200	18500	32700		
1990		14200	18500	32700		
1991		14200	18500	32700		
1992		14200	18500	32700		
1993		14200	18500	32700		
1994	159000	14200	18500	191700		
1995		14200	18500	32700		
1996		14200	18500	32700		
1997		14200	18500	32700		
1998		14200	18500	32700		
1999		14200	18500	32700		
2000		14200	18500	32700		
2001		14200	18500	32700		
2002		14200	18500	32700		
2003		14200	18500	32700		
2004		14200	18500	32700		
2005		14200	18500	32700		
2006		14200	18500	32700		
2007		14200	18500	32700		
2008		14200	18500	32700		
2009		14200	18500	32700		
2010		14200	18500	32700		
2011		14200	18500	32700		
2012		14200	18500	32700		
2013		14200	18500	32700		
2014		14200	18500	32700		
2015		14200	18500	32700		
2016		14200	18500	32700		
2017		14200	18500	32700		
2018		14200	18500	32700		
2019		14200	18500	32700		
2020		14200	18500	32700		
2021		14200	18500	32700		
2022		14200	18500	32700		
2023		14200	18500	32700		
2024		14200	18500	32700		
2025		14200	18500	32700		
2026		14200	18500	32700		
Total	9699000	604600	833750	11137350		
Net present cost				7787512.	1.580245	13.74768

Table D-12

Net Present Cost
Alternate C--1000 Feet South of Tomlinson Bridge
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	2189000	12200	31250	2232450		
1985	1167000	12200	31250	1210450		
1986	26025000	12200	31250	26068450		
1987		10500	11750	22250		
1988		10500	11750	22250		
1989		10500	11750	22250		
1990		10500	11750	22250		
1991		10500	11750	22250		
1992		10500	11750	22250		
1993		10500	11750	22250		
1994	159000	10500	11750	181250		
1995		10500	11750	22250		
1996		10500	11750	22250		
1997		10500	11750	22250		
1998		10500	11750	22250		
1999		10500	11750	22250		
2000		10500	11750	22250		
2001		10500	11750	22250		
2002		10500	11750	22250		
2003		10500	11750	22250		
2004		10500	11750	22250		
2005		10500	11750	22250		
2006		10500	11750	22250		
2007		10500	11750	22250		
2008		10500	11750	22250		
2009		10500	11750	22250		
2010		10500	11750	22250		
2011		10500	11750	22250		
2012		10500	11750	22250		
2013		10500	11750	22250		
2014		10500	11750	22250		
2015		10500	11750	22250		
2016		10500	11750	22250		
2017		10500	11750	22250		
2018		10500	11750	22250		
2019		10500	11750	22250		
2020		10500	11750	22250		
2021		10500	11750	22250		
2022		10500	11750	22250		
2023		10500	11750	22250		
2024		10500	11750	22250		
2025		10500	11750	22250		
2026		10500	11750	22250		
Total	29540000	456600	563750	30560350		
Net present cost				22834687	4.712691	40.99290

Table D-15

Net Present Cost
Alternate D--Manufacturers Spur
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1878000	12200	31250	1921450		
1985	367000	12200	31250	410450		
1986	21595000	12200	31250	21638450		
1987		19700	18500	38200		
1988		19700	18500	38200		
1989		19700	18500	38200		
1990		19700	18500	38200		
1991		19700	18500	38200		
1992		19700	18500	38200		
1993		19700	18500	38200		
1994	159000	19700	18500	197200		
1995		19700	18500	38200		
1996		19700	18500	38200		
1997		19700	18500	38200		
1998		19700	18500	38200		
1999		19700	18500	38200		
2000		19700	18500	38200		
2001		19700	18500	38200		
2002		19700	18500	38200		
2003		19700	18500	38200		
2004		19700	18500	38200		
2005		19700	18500	38200		
2006		19700	18500	38200		
2007		19700	18500	38200		
2008		19700	18500	38200		
2009		19700	18500	38200		
2010		19700	18500	38200		
2011		19700	18500	38200		
2012		19700	18500	38200		
2013		19700	18500	38200		
2014		19700	18500	38200		
2015		19700	18500	38200		
2016		19700	18500	38200		
2017		19700	18500	38200		
2018		19700	18500	38200		
2019		19700	18500	38200		
2020		19700	18500	38200		
2021		19700	18500	38200		
2022		19700	18500	38200		
2023		19700	18500	38200		
2024		19700	18500	38200		
2025		19700	18500	38200		
2026		19700	18500	38200		
Total	23999000	824600	833750	25657350		
Net present cost				18679665	3.790486	32.97614

Table D-14

Net Present Cost
Alternate E-Immediately North of Tomlinson Bridge
600 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1418000	12200	31250	1461450		
1985	801000	12200	31250	844450		
1986	17688000	12200	31250	17731450		
1987		10300	13250	23550		
1988		10300	13250	23550		
1989		10300	13250	23550		
1990		10300	13250	23550		
1991		10300	13250	23550		
1992		10300	13250	23550		
1993		10300	13250	23550		
1994	159000	10300	13250	182550		
1995		10300	13250	23550		
1996		10300	13250	23550		
1997		10300	13250	23550		
1998		10300	13250	23550		
1999		10300	13250	23550		
2000		10300	13250	23550		
2001		10300	13250	23550		
2002		10300	13250	23550		
2003		10300	13250	23550		
2004		10300	13250	23550		
2005		10300	13250	23550		
2006		10300	13250	23550		
2007		10300	13250	23550		
2008		10300	13250	23550		
2009		10300	13250	23550		
2010		10300	13250	23550		
2011		10300	13250	23550		
2012		10300	13250	23550		
2013		10300	13250	23550		
2014		10300	13250	23550		
2015		10300	13250	23550		
2016		10300	13250	23550		
2017		10300	13250	23550		
2018		10300	13250	23550		
2019		10300	13250	23550		
2020		10300	13250	23550		
2021		10300	13250	23550		
2022		10300	13250	23550		
2023		10300	13250	23550		
2024		10300	13250	23550		
2025		10300	13250	23550		
2026		10300	13250	23550		
Total	20066000	448600	623750	21138350		
Net present cost				15577138	3.214857	27.96413

Table 15

Net Present Cost
Tomlinson Bridge--Current Rail
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984		14570	83300	97870		
1985		14570	83300	97870		
1986		14570	83300	97870		
1987		14570	83300	97870		
1988		14570	83300	97870		
1989		14570	83300	97870		
1990		14570	83300	97870		
1991		14570	83300	97870		
1992		14570	83300	97870		
1993		14570	83300	97870		
1994	1403500	14570	83300	1501370		
1995		14570	83300	97870		
1996		14570	83300	97870		
1997		14570	83300	97870		
1998		14570	83300	97870		
1999		14570	83300	97870		
2000		14570	83300	97870		
2001		14570	83300	97870		
2002		14570	83300	97870		
2003		14570	83300	97870		
2004		14570	83300	97870		
2005		14570	83300	97870		
2006		14570	83300	97870		
2007		14570	83300	97870		
2008		14570	83300	97870		
2009		14570	83300	97870		
2010		14570	83300	97870		
2011		14570	83300	97870		
2012		14570	83300	97870		
2013		14570	83300	97870		
2014		14570	83300	97870		
2015		14570	83300	97870		
2016		14570	83300	97870		
2017		14570	83300	97870		
2018		14570	83300	97870		
2019		14570	83300	97870		
2020		14570	83300	97870		
2021		14570	83300	97870		
2022		14570	83300	97870		
2023		14570	83300	97870		
2024		14570	83300	97870		
2025		14570	83300	97870		
2026		14570	83300	97870		
Total	1403500	626510	3581900	5611910		
Net present cost				1454372.	.1261949	1.102799

Table 16

Net Present Cost
Tomlinson Bridge--Heavy Rail
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	573000	14570	83300	670870		
1985	54000	14570	83300	151870		
1986	6604000			6604000		
1987		14570	15330	29900		
1988		14570	15330	29900		
1989		14570	15330	29900		
1990		14570	15330	29900		
1991		14570	15330	29900		
1992		14570	15330	29900		
1993		14570	15330	29900		
1994	391460	14570	15330	421360		
1995		14570	15330	29900		
1996		14570	15330	29900		
1997		14570	15330	29900		
1998		14570	15330	29900		
1999		14570	15330	29900		
2000		14570	15330	29900		
2001		14570	15330	29900		
2002		14570	15330	29900		
2003		14570	15330	29900		
2004		14570	15330	29900		
2005		14570	15330	29900		
2006		14570	15330	29900		
2007		14570	15330	29900		
2008		14570	15330	29900		
2009		14570	15330	29900		
2010		14570	15330	29900		
2011		14570	15330	29900		
2012		14570	15330	29900		
2013		14570	15330	29900		
2014		14570	15330	29900		
2015		14570	15330	29900		
2016		14570	15330	29900		
2017		14570	15330	29900		
2018		14570	15330	29900		
2019		14570	15330	29900		
2020		14570	15330	29900		
2021		14570	15330	29900		
2022		14570	15330	29900		
2023		14570	15330	29900		
2024		14570	15330	29900		
2025		14570	15330	29900		
2026		14570	15330	29900		
Total	7622460	611940	779800	9014200		
Net present cost				6053961.	.3748304	3.260427

Table 17

Net Present Cost
Alternate A--Immediately South of Tomlinson Bridge
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per pounds	000 gallons
1984	1393000	14570	83300	1490870		
1985	154000	14570	83300	251870		
1986	16022000			16022000		
1987		14570	15330	29900		
1988		14570	15330	29900		
1989		14570	15330	29900		
1990		14570	15330	29900		
1991		14570	15330	29900		
1992		14570	15330	29900		
1993		14570	15330	29900		
1994	391500	14570	15330	421400		
1995		14570	15330	29900		
1996		14570	15330	29900		
1997		14570	15330	29900		
1998		14570	15330	29900		
1999		14570	15330	29900		
2000		14570	15330	29900		
2001		14570	15330	29900		
2002		14570	15330	29900		
2003		14570	15330	29900		
2004		14570	15330	29900		
2005		14570	15330	29900		
2006		14570	15330	29900		
2007		14570	15330	29900		
2008		14570	15330	29900		
2009		14570	15330	29900		
2010		14570	15330	29900		
2011		14570	15330	29900		
2012		14570	15330	29900		
2013		14570	15330	29900		
2014		14570	15330	29900		
2015		14570	15330	29900		
2016		14570	15330	29900		
2017		14570	15330	29900		
2018		14570	15330	29900		
2019		14570	15330	29900		
2020		14570	15330	29900		
2021		14570	15330	29900		
2022		14570	15330	29900		
2023		14570	15330	29900		
2024		14570	15330	29900		
2025		14570	15330	29900		
2026		14570	15330	29900		
Total	17960500	611940	779800	19352240		
Net present cost				13957957	.8642056	7.517211

Table 18

Net Present Cost
Alternate B--Inland Route
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	641000	14570	83300	738870		
1985	1528000	14570	83300	1625870		
1986	7371000	14200	83300	7468500		
1987		14200	18500	32700		
1988		14200	18500	32700		
1989		14200	18500	32700		
1990		14200	18500	32700		
1991		14200	18500	32700		
1992		14200	18500	32700		
1993		14200	18500	32700		
1994	391460	14200	18500	424160		
1995		14200	18500	32700		
1996		14200	18500	32700		
1997		14200	18500	32700		
1998		14200	18500	32700		
1999		14200	18500	32700		
2000		14200	18500	32700		
2001		14200	18500	32700		
2002		14200	18500	32700		
2003		14200	18500	32700		
2004		14200	18500	32700		
2005		14200	18500	32700		
2006		14200	18500	32700		
2007		14200	18500	32700		
2008		14200	18500	32700		
2009		14200	18500	32700		
2010		14200	18500	32700		
2011		14200	18500	32700		
2012		14200	18500	32700		
2013		14200	18500	32700		
2014		14200	18500	32700		
2015		14200	18500	32700		
2016		14200	18500	32700		
2017		14200	18500	32700		
2018		14200	18500	32700		
2019		14200	18500	32700		
2020		14200	18500	32700		
2021		14200	18500	32700		
2022		14200	18500	32700		
2023		14200	18500	32700		
2024		14200	18500	32700		
2025		14200	18500	32700		
2026		14200	18500	32700		
Total	9931460	611340	989900	11532700		
Net present cost				8004045.	.4872553	4.238981

Table 19

Net Present Cost
Alternate C--1000 Feet South of Tomlinson Bridge
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	2189000	14570	83300	2286870		
1985	1167000	14570	83300	1264870		
1986	26025000	14570	83300	26122870		
1987		12870	13830	26700		
1988		12870	13830	26700		
1989		12870	13830	26700		
1990		12870	13830	26700		
1991		12870	13830	26700		
1992		12870	13830	26700		
1993		12870	13830	26700		
1994	391500	12870	13830	418200		
1995		12870	13830	26700		
1996		12870	13830	26700		
1997		12870	13830	26700		
1998		12870	13830	26700		
1999		12870	13830	26700		
2000		12870	13830	26700		
2001		12870	13830	26700		
2002		12870	13830	26700		
2003		12870	13830	26700		
2004		12870	13830	26700		
2005		12870	13830	26700		
2006		12870	13830	26700		
2007		12870	13830	26700		
2008		12870	13830	26700		
2009		12870	13830	26700		
2010		12870	13830	26700		
2011		12870	13830	26700		
2012		12870	13830	26700		
2013		12870	13830	26700		
2014		12870	13830	26700		
2015		12870	13830	26700		
2016		12870	13830	26700		
2017		12870	13830	26700		
2018		12870	13830	26700		
2019		12870	13830	26700		
2020		12870	13830	26700		
2021		12870	13830	26700		
2022		12870	13830	26700		
2023		12870	13830	26700		
2024		12870	13830	26700		
2025		12870	13830	26700		
2026		12870	13830	26700		
Total	29772500	558510	803100	31134110		
Net present cost				23084206	1.405277	12.22551

Table 20

Net Present Cost
Alternate D--Manufacturers Spur
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1878000	14570	83300	1975870		
1985	367000	14570	83300	464870		
1986	21595000	14570	83300	21692870		
1987		19700	18500	38200		
1988		19700	18500	38200		
1989		19700	18500	38200		
1990		19700	18500	38200		
1991		19700	18500	38200		
1992		19700	18500	38200		
1993		19700	18500	38200		
1994	391500	19700	18500	429700		
1995		19700	18500	38200		
1996		19700	18500	38200		
1997		19700	18500	38200		
1998		19700	18500	38200		
1999		19700	18500	38200		
2000		19700	18500	38200		
2001		19700	18500	38200		
2002		19700	18500	38200		
2003		19700	18500	38200		
2004		19700	18500	38200		
2005		19700	18500	38200		
2006		19700	18500	38200		
2007		19700	18500	38200		
2008		19700	18500	38200		
2009		19700	18500	38200		
2010		19700	18500	38200		
2011		19700	18500	38200		
2012		19700	18500	38200		
2013		19700	18500	38200		
2014		19700	18500	38200		
2015		19700	18500	38200		
2016		19700	18500	38200		
2017		19700	18500	38200		
2018		19700	18500	38200		
2019		19700	18500	38200		
2020		19700	18500	38200		
2021		19700	18500	38200		
2022		19700	18500	38200		
2023		19700	18500	38200		
2024		19700	18500	38200		
2025		19700	18500	38200		
2026		19700	18500	38200		
Total	24231500	831710	989900	26053110		
Net present cost				18896489	1.150345	10.00767

Table 21

Net Present Cost
Alternate E-Immediately North of Tomlinson Bridge
2000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1418000	14570	83300	1515870		
1985	801000	14570	83300	898870		
1986	17688000	0	0	17688000		
1987		11350	15330	26680		
1988		11350	15330	26680		
1989		11350	15330	26680		
1990		11350	15330	26680		
1991		11350	15330	26680		
1992		11350	15330	26680		
1993		11350	15330	26680		
1994	391500	11350	15330	418180		
1995		11350	15330	26680		
1996		11350	15330	26680		
1997		11350	15330	26680		
1998		11350	15330	26680		
1999		11350	15330	26680		
2000		11350	15330	26680		
2001		11350	15330	26680		
2002		11350	15330	26680		
2003		11350	15330	26680		
2004		11350	15330	26680		
2005		11350	15330	26680		
2006		11350	15330	26680		
2007		11350	15330	26680		
2008		11350	15330	26680		
2009		11350	15330	26680		
2010		11350	15330	26680		
2011		11350	15330	26680		
2012		11350	15330	26680		
2013		11350	15330	26680		
2014		11350	15330	26680		
2015		11350	15330	26680		
2016		11350	15330	26680		
2017		11350	15330	26680		
2018		11350	15330	26680		
2019		11350	15330	26680		
2020		11350	15330	26680		
2021		11350	15330	26680		
2022		11350	15330	26680		
2023		11350	15330	26680		
2024		11350	15330	26680		
2025		11350	15330	26680		
2026		11350	15330	26680		
Total	20298500	483140	779800	21561440		
Net present cost				15743428	.9748253	8.478796

Table 22

Net Present Cost
Tomlinson Bridge--Current Rail
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984		16440	164860	181300		
1985		16440	164860	181300		
1986		16440	164860	181300		
1987		16440	164860	181300		
1988		16440	164860	181300		
1989		16440	164860	181300		
1990		16440	164860	181300		
1991		16440	164860	181300		
1992		16440	164860	181300		
1993		16440	164860	181300		
1994	1583300	16440	164860	1764600		
1995		16440	164860	181300		
1996		16440	164860	181300		
1997		16440	164860	181300		
1998		16440	164860	181300		
1999		16440	164860	181300		
2000		16440	164860	181300		
2001		16440	164860	181300		
2002		16440	164860	181300		
2003		16440	164860	181300		
2004		16440	164860	181300		
2005		16440	164860	181300		
2006		16440	164860	181300		
2007		16440	164860	181300		
2008		16440	164860	181300		
2009		16440	164860	181300		
2010		16440	164860	181300		
2011		16440	164860	181300		
2012		16440	164860	181300		
2013		16440	164860	181300		
2014		16440	164860	181300		
2015		16440	164860	181300		
2016		16440	164860	181300		
2017		16440	164860	181300		
2018		16440	164860	181300		
2019		16440	164860	181300		
2020		16440	164860	181300		
2021		16440	164860	181300		
2022		16440	164860	181300		
2023		16440	164860	181300		
2024		16440	164860	181300		
2025		16440	164860	181300		
2026		16440	164860	181300		
Total	1583300	706920	7088980	9379200		
Net present cost				2337841.	.1012052	.8863515

Table 23

Net Present Cost
Tomlinson Bridge--Heavy Rail
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	573000	16440	164860	754300		
1985	54000	16440	164860	235300		
1986	6604000	0	0	6604000		
1987		16440	33720	50160		
1988		16440	33720	50160		
1989		16440	33720	50160		
1990		16440	33720	50160		
1991		16440	33720	50160		
1992		16440	33720	50160		
1993		16440	33720	50160		
1994	571300	16440	33720	621460		
1995		16440	33720	50160		
1996		16440	33720	50160		
1997		16440	33720	50160		
1998		16440	33720	50160		
1999		16440	33720	50160		
2000		16440	33720	50160		
2001		16440	33720	50160		
2002		16440	33720	50160		
2003		16440	33720	50160		
2004		16440	33720	50160		
2005		16440	33720	50160		
2006		16440	33720	50160		
2007		16440	33720	50160		
2008		16440	33720	50160		
2009		16440	33720	50160		
2010		16440	33720	50160		
2011		16440	33720	50160		
2012		16440	33720	50160		
2013		16440	33720	50160		
2014		16440	33720	50160		
2015		16440	33720	50160		
2016		16440	33720	50160		
2017		16440	33720	50160		
2018		16440	33720	50160		
2019		16440	33720	50160		
2020		16440	33720	50160		
2021		16440	33720	50160		
2022		16440	33720	50160		
2023		16440	33720	50160		
2024		16440	33720	50160		
2025		16440	33720	50160		
2026		16440	33720	50160		
Total	7802300	690480	1678520	10171300		
Net present cost				6410643.	.1984572	1.726261

Table 24

Net Present Cost
Alternate A--Immediately South of Tomlinson Bridge
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1393000	16440	164860	1574300		
1985	154000	16440	164860	335300		
1986	16022000	0	0	16022000		
1987		14570	33720	48290		
1988		14570	33720	48290		
1989		14570	33720	48290		
1990		14570	33720	48290		
1991		14570	33720	48290		
1992		14570	33720	48290		
1993		14570	33720	48290		
1994	571300	14570	33720	619590		
1995		14570	33720	48290		
1996		14570	33720	48290		
1997		14570	33720	48290		
1998		14570	33720	48290		
1999		14570	33720	48290		
2000		14570	33720	48290		
2001		14570	33720	48290		
2002		14570	33720	48290		
2003		14570	33720	48290		
2004		14570	33720	48290		
2005		14570	33720	48290		
2006		14570	33720	48290		
2007		14570	33720	48290		
2008		14570	33720	48290		
2009		14570	33720	48290		
2010		14570	33720	48290		
2011		14570	33720	48290		
2012		14570	33720	48290		
2013		14570	33720	48290		
2014		14570	33720	48290		
2015		14570	33720	48290		
2016		14570	33720	48290		
2017		14570	33720	48290		
2018		14570	33720	48290		
2019		14570	33720	48290		
2020		14570	33720	48290		
2021		14570	33720	48290		
2022		14570	33720	48290		
2023		14570	33720	48290		
2024		14570	33720	48290		
2025		14570	33720	48290		
2026		14570	33720	48290		
Total	18140300	615680	1678520	20434500		
Net present cost				14300886	.4427190	3.850949

Table 25

Net Present Cost
Alternate B--Inland Route
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	641000	16440	164860	822300		
1985	1528000	16440	164860	1709300		
1986	7371000	16440	164860	7552300		
1987		14200	37000	51200		
1988		14200	37000	51200		
1989		14200	37000	51200		
1990		14200	37000	51200		
1991		14200	37000	51200		
1992		14200	37000	51200		
1993		14200	37000	51200		
1994	391460	14200	37000	442660		
1995		14200	37000	51200		
1996		14200	37000	51200		
1997		14200	37000	51200		
1998		14200	37000	51200		
1999		14200	37000	51200		
2000		14200	37000	51200		
2001		14200	37000	51200		
2002		14200	37000	51200		
2003		14200	37000	51200		
2004		14200	37000	51200		
2005		14200	37000	51200		
2006		14200	37000	51200		
2007		14200	37000	51200		
2008		14200	37000	51200		
2009		14200	37000	51200		
2010		14200	37000	51200		
2011		14200	37000	51200		
2012		14200	37000	51200		
2013		14200	37000	51200		
2014		14200	37000	51200		
2015		14200	37000	51200		
2016		14200	37000	51200		
2017		14200	37000	51200		
2018		14200	37000	51200		
2019		14200	37000	51200		
2020		14200	37000	51200		
2021		14200	37000	51200		
2022		14200	37000	51200		
2023		14200	37000	51200		
2024		14200	37000	51200		
2025		14200	37000	51200		
2026		14200	37000	51200		
Total	9931460	617320	1974580	12523360		
Net present cost				8347723.	.2540885	2.210498

Table 26

Net Present Cost
Alternate C--1000 Feet South of Tomlinson Bridge
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	2189000	16640	164860	2370500		
1985	1167000	16640	164860	1348500		
1986	26025000	16640	164860	26206500		
1987		14740	30720	45460		
1988		14740	30720	45460		
1989		14740	30720	45460		
1990		14740	30720	45460		
1991		14740	30720	45460		
1992		14740	30720	45460		
1993		14740	30720	45460		
1994	571300	14740	30720	616760		
1995		14740	30720	45460		
1996		14740	30720	45460		
1997		14740	30720	45460		
1998		14740	30720	45460		
1999		14740	30720	45460		
2000		14740	30720	45460		
2001		14740	30720	45460		
2002		14740	30720	45460		
2003		14740	30720	45460		
2004		14740	30720	45460		
2005		14740	30720	45460		
2006		14740	30720	45460		
2007		14740	30720	45460		
2008		14740	30720	45460		
2009		14740	30720	45460		
2010		14740	30720	45460		
2011		14740	30720	45460		
2012		14740	30720	45460		
2013		14740	30720	45460		
2014		14740	30720	45460		
2015		14740	30720	45460		
2016		14740	30720	45460		
2017		14740	30720	45460		
2018		14740	30720	45460		
2019		14740	30720	45460		
2020		14740	30720	45460		
2021		14740	30720	45460		
2022		14740	30720	45460		
2023		14740	30720	45460		
2024		14740	30720	45460		
2025		14740	30720	45460		
2026		14740	30720	45460		
Total	29952300	639520	1723380	32315200		
Net present cost				23493033	.7151608	6.221013

Table 27

Net Present Cost
Alternate D--Manufacturers Spur
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1878000	16440	164860	2059300		
1985	367000	16440	164860	548300		
1986	21595000	16440	164860	21776300		
1987		19700	37000	56700		
1988		19700	37000	56700		
1989		19700	37000	56700		
1990		19700	37000	56700		
1991		19700	37000	56700		
1992		19700	37000	56700		
1993		19700	37000	56700		
1994	391500	19700	37000	448200		
1995		19700	37000	56700		
1996		19700	37000	56700		
1997		19700	37000	56700		
1998		19700	37000	56700		
1999		19700	37000	56700		
2000		19700	37000	56700		
2001		19700	37000	56700		
2002		19700	37000	56700		
2003		19700	37000	56700		
2004		19700	37000	56700		
2005		19700	37000	56700		
2006		19700	37000	56700		
2007		19700	37000	56700		
2008		19700	37000	56700		
2009		19700	37000	56700		
2010		19700	37000	56700		
2011		19700	37000	56700		
2012		19700	37000	56700		
2013		19700	37000	56700		
2014		19700	37000	56700		
2015		19700	37000	56700		
2016		19700	37000	56700		
2017		19700	37000	56700		
2018		19700	37000	56700		
2019		19700	37000	56700		
2020		19700	37000	56700		
2021		19700	37000	56700		
2022		19700	37000	56700		
2023		19700	37000	56700		
2024		19700	37000	56700		
2025		19700	37000	56700		
2026		19700	37000	56700		
Total	24231500	837320	1974580	27043400		
Net present cost				19239889	.5856892	5.094770

Table 28

Net Present Cost
Alternate E-Immediately North of Tomlinson Bridge
4000 Cars Per Year

Year	Capital	Mainten	Operat	Total	cost per 000 pounds	gallons
1984	1418000	16440	164860	1599300		
1985	801000	16440	164860	982300		
1986	17688000	0	0	17688000		
1987		11350	33720	45070		
1988		11350	33720	45070		
1989		11350	33720	45070		
1990		11350	33720	45070		
1991		11350	33720	45070		
1992		11350	33720	45070		
1993		11350	33720	45070		
1994	571300	11350	33720	616370		
1995		11350	33720	45070		
1996		11350	33720	45070		
1997		11350	33720	45070		
1998		11350	33720	45070		
1999		11350	33720	45070		
2000		11350	33720	45070		
2001		11350	33720	45070		
2002		11350	33720	45070		
2003		11350	33720	45070		
2004		11350	33720	45070		
2005		11350	33720	45070		
2006		11350	33720	45070		
2007		11350	33720	45070		
2008		11350	33720	45070		
2009		11350	33720	45070		
2010		11350	33720	45070		
2011		11350	33720	45070		
2012		11350	33720	45070		
2013		11350	33720	45070		
2014		11350	33720	45070		
2015		11350	33720	45070		
2016		11350	33720	45070		
2017		11350	33720	45070		
2018		11350	33720	45070		
2019		11350	33720	45070		
2020		11350	33720	45070		
2021		11350	33720	45070		
2022		11350	33720	45070		
2023		11350	33720	45070		
2024		11350	33720	45070		
2025		11350	33720	45070		
2026		11350	33720	45070		
Total	20478300	486880	1678520	22643700		
Net present cost				16086356	.4980296	4.227022

Table 29

COST SUMMARY

Alternate	Cost (millions) Total 42 yrs.	Current disctd.	Cost per 1,000 Pounds Scrap	Gallons #2 Oil
600 Cars Per Year				
Current Bridge operations	$ 3.0	$ 0.8	$ 0.24	$ 2.12
Tomlinson improved for heavy rail	8.5	5.8	1.20	10.50
Alt. A: s/o Tomlinson Bridge	18.8	13.7	2.84	24.68
Alt. B: Inland Route	11.1	7.8	1.58	13.75
Alt. C: 1000' s/o Tomlinson Bridge	30.6	22.8	4.71	40.99
Alt. D: Manufacturers spur	25.7	18.7	3.79	32.98
Alt. E: n/o Tomlinson Bridge	21.1	15.6	3.21	27.96
2000 Cars Per Year				
Current Bridge operations	$ 5.6	$ 1.5	$ 0.13	$ 1.10
Tomlinson improved for heavy rail	9.0	6.1	0.37	3.26
Alt. A: s/o Tomlinson Bridge	19.4	14.0	0.86	7.52
Alt. B: Inland Route	11.5	8.0	0.49	4.24
Alt. C: 1000' s/o Tomlinson Bridge	31.1	23.1	1.41	12.23
Alt. D: Manufacturers spur	26.1	18.9	1.15	10.00
Alt. E: n/o Tomlinson Bridge	21.6	15.7	0.97	8.48
4000 Cars Per Year				
Current Bridge operations	$ 9.4	$ 2.3	$ 0.10	$ 0.89
Tomlinson improved for heavy rail	10.2	6.4	0.20	1.73
Alt. A: s/o Tomlinson Bridge	20.4	14.3	0.44	3.85
Alt. B: Inland Route	12.5	8.3	0.25	2.21
Alt. C: 1000' s/o Tomlinson Bridge	32.3	23.5	0.71	6.22
Alt. D: Manufacturers spur	27.0	19.2	0.59	5.09
Alt. E: n/o Tomlinson Bridge	22.6	16.1	0.50	4.33

Appendix E

Right-Of-Way Costs

Tables E-1 thru E-5 suggest-right-of-way acquisition costs associated with five improvement options. Data drawn from the City of New Haven Tax Assessors office:

- reflect information for the full parcel impacted by rail improvement activities.

- suggest the extent and cost of necessary acquisition. Land taking costs reflect a pro-rate apportionment of current assessed value adjusted by a 2.5-to-1 estimate of "market-to-assessed" value relationships.

TABLE E-1
ALTERNATE A
IMPROVE TOMLINSON BRIDGE

Tax							Parcel (000's)			Taking		
Map	Block	Parcel	Address	Owner	Use	Sq.ft.	Land	Impr.	Total	Type	Cost	Notes
							$	$	$		$	
81	954	1	85 Forbes Ave	Getty Oil Company	Fuel loading	97.4	102.3	266.0	368.4	partial	33.6	12,800 sq.ft. strips Tanks 20-30' from road
177	530	4.01	Forbes Ave	Wyatt Term. Corp.	Vacant portion of parcel	210.8	201.6	604.6	806.2	partial	5.8	2,400 sq.ft. strips
81	974	2	120 Forbes Ave	Texaco Inc.	Fuel loading	272.6	146.7	207.9	354.6	partial	1.9	1,400 sq.ft. strips
81	974	3	134 Forbes Ave	Mobil Oil Corp	Fuel loading	520.4	483.5	914.2	1397.8	partial	10.2	4,400 sq.ft. strips
81	974	5	Forbes Ave	Conrail	Vacant	12.3	6.5	-	6.5	partial	1.0	800 sq.ft. strips
77	973	10	172 Forbes Ave	Dahill Enterprises	Vacant area behind main building	67.1	56.9	107.4	164.3	partial	34.1	16,100 sq.ft. major take
82	974	20	238 Fairmont Ave	City of New Haven	Former U.S. Steel site	1,662.9	814.4	801.0	1615.4	partial	28.9	23,600 sq.ft.
											$115.5	

TABLE E-2
ALTERNATE B
INLAND ROUTE

Map	Tax Block	Parcel	Address	Owner	Use	Sq.ft.	Parcel (000's) Land $	Impr. $	Total $	Taking Type	Cost $	Notes
81	974	1	Forbes Ave	United Illuminating	Vacant	32.0	25.9	-	25.9	partial	10.7	6,000 sq.ft.
81	974	2	120 Forbes Ave	Texaco Inc.	Tanks & pipelines to river	272.6	146.7	207.9	354.6	partial	6.5	4,800 strips and relocate pipelines
176	974	3	134 Forbes Ave	Mobil Oil Corp	Tanks & pipelines to river	520.4	483.5	914.2	1397.7	partial	27.5	strip and relocate pipelines
83	974	20	238 Fairmount Ave	City of New Haven	Former U.S. Steel site	1662.9	814.4	801.0	1615.4	partial	28.9	23,600 sq.ft.
83	974	1	70 Ferry Street	Tilcon Minerals	Industrial	58.0	55.0	30.9	85.9	full	214.8	
91	995	12.01	Ferry Street	William Goodrich	Vacant	10.2	7.6	-	7.6	full	19.2	
91	995	12	39 Ferry Street	William Goodrich	Goodrich Oil	78.0	64.7	111.5	176.2	full	440.5	
91	995	11 & 11.1	17, 19, 27 Ferry Street	William Goodrich	Industrial/commercial	23.7	22.4	38.7	61.1	full	153.0	
91	996	3	Quinnipiac Ave	Elm City Oil	Gas Station	6.6	8.7	-	8.7	full	14.2	Parking Area
91	996	2	Quinnipiac Ave	Elm City Oil	Gas Station	6.9	7.2	18.8	26.0	full	65.0	
91	996	28	Lenox Street	Jet Lines Inc.	Pipeline	54.5	11.4	-	11.4	partial	1.8	Strip & relocate pipeline
85	997	4	Russell Street	Jet Lines Inc.	Pipeline	48.8	10.2	-	10.2	full	25.6	Relocate pipeline
86	984	4.01	Russell Street	Jet Lines Inc.	Pipeline	43.6	9.1	-	9.1	full	22.9	Relocate pipeline
86	983	2	Burnell Street	New Haven Terminal	Pipeline	88.4	14.0	-	14.0	full	35.0	Relocate pipeline
260	3410	1	Frontage Road (East Haven)	New Haven Terminal	Pipeline	2308.7	272.5	1001.9	1274.4	partial	118.0	Take R-O-W 2200' long and 70' wide
181	954	2.1	85 Forbes Ave	Getty Oil Corp.	Fuel loading	97.4	102.3	266.0	368.4	partial	10.5	4,000 sq.ft. strip
									$1146.0			

TABLE E-3
ALTERNATE C
1000 FEET SOUTH OF TOMLINSON

Tax						Parcel (000's)				Taking		
Map	Block	Parcel	Address	Owner	Use	Sq.ft.	Land	Impr.	Total	Type	Cost	Notes
							$	$	$		$	
78	1400	3.1	Waterfront Street	Gulf Oil Cor.	Parcel Lot	184.3	397.4	72.8	470.2	partial	444.8	82,500 sq.ft.
80	1300	1	Waterfront Street	Conrail	Switching yard	164.1	172.3	--	172.3	full	430.7	

TABLE E-4
ALTERNATE D
MANUFACTURERS SPUR

Tax Map	Block	Parcel	Address	Owner	Use	Parcel (000's) Sq.ft.	Land $	Impr. $	Total $	Taking Type	Cost $	Notes
81	954	1	85 Forbes Ave	Getty Oil Company	Fuel loading	97.4	102.3	266.0	368.4	partial	10.4	4,000 sq.ft.
81	974	1	Forbes Ave	United Illuminating	Vacant	32.0	25.9	-	25.9	partial	10.7	6,000 sq.ft.
81	974	1	120 Forbes Ave	Texaco, Inc.	Pipeline to river	272.6	146.7	207.9	354.6	partial	6.5	4,000 sq.ft. and retain river access
175	607	1	Chapel Street	City of New Haven	Quinnipiac Park	413.6	320.2	66.3	386.5	partial	124.6	64,000 sq.ft.
174	709	4	Chapel Street	Conrail	Rail	13.3	6.5	-	6.5	full	-	
176	974	3	134 Forbes Ave	Mobil Oil Corp	Pipeline to river	520.4	483.5	914.2	1139.7	partial	79.4	34,200 sq.ft. and maintain river access
83	974	20	238 Fairmount Ave	City of New Haven	Former U.S. Steel site	1662.9	814.4	801.0	1615.4	partial	43.4	35,000 sq.ft.
											$275.1	

TABLE E-5
ALTERNATE E
IMMEDIATELY NORTH OF TOMLINSON

Tax						Parcel (000's)				Taking		
Map	Block	Parcel	Address	Owner	Use	Sq.ft.	Land $	Impr. $	Total $	Type	Cost $	Notes
81	974	1	Forbes Ave	United Illuminating Co.	Fuel Loading	32.0	25.9	-	25.9	partial	14.2	Maintain access
81	974	1.01	74 Forbes Ave	Redden Brothers	Commercial-office	58.7	46.1	107.4	153.5	full	700.0	Beyond multiplier in view of rehab.
177	1300	1	Forbes Ave	Conrail	Bill Board	601.2	631.3	-	631.3	partial	10.5	
81	974	2	120 Forbes Ave	Texaco Inc.	Fuel loading	272.6	146.7	207.9	354.6	partial	3.2	Maintain access
81	974	3	134 Forbes Ave	Mobil Oil Corp.	Fuel loading	520.4	483.5	914.2	1397.7	partial	10.2	Maintain access
81	974	5	Forbes Ave	Conrail	Vacant	12.3	6.5	-	6.5	partial	1.0	
77	973	10	172 Forbes Ave	Dahill Enterprises	Vacant area behind main bldg.	67.1	56.9	107.4	164.3	partial	35.6	16,800 sq.ft. major take
82	974	-	238 Forbes Ave	City of New Haven	Former U.S. Steel Site	1662.9	814.4	801.0	1615.4	partial	26.0	Maintain access
											$800.7	